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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr' a
10^{9}	giga	G	jĭ' ga
10^{6}	mega	M	mĕg' a
10^{3}	kilo	k	kĭl' o
10^{2}	hecto	h	hĕk' to
10	deka	da	dĕk' a
10^{-1}	deci	d	dĕs' i
10^{-2}	centi	c	sĕn' ti
10^{-3}	milli	m	mĭl' i
10^{-6}	micro	μ	mī' kro
10^{-9}	nano	n	năn' o
10^{-12}	pico	p	pē' co
10^{-15}	femto	f	fĕm' to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g=2.205 lb
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 mCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie=2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 9, Number 6, June 1968

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the National Center for Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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Public Health Service • National Center for Radiological Health

SECTION I. MILK AND FOOD

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Federal and State agencies are involved in efforts to monitor continuously the dietary intake of radionuclides. The most direct measure of radionuclide intake would be obtained through radioanalysis of the total diet. Difficulties in obtaining specific dietary data impede this approach. An alternate method entails the use of indicator foods to arrive at an estimate of the total dietary radionuclide intake.

Fresh milk is one such indicator food. It is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides which appear in the diet. It also is one of the major sources of dietary intake for the short-lived radionuclides. For these reasons, fresh milk is the single food item most often used in estimating the intake of selected radionuclides by the general population and/or specific population groups. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of fresh milk.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission on Radiological Protection (*5, 6*).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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(*5*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 2. Pergamon Press, New York, N.Y. (1959).

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National and International Milk Surveillance

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide levels in milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in milk, *HASL*	July–December 1966	September 1967

1. Pasteurized Milk Network
February 1968

National Center for Radiological Health and *National Center for Urban and Industrial Health, PHS*

The Public Health Service's Pasteurized Milk Network (PMN) is designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 stations (figure 1) provides data on milk in every State, Washington, D. C., the Canal Zone, and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the January 1968 issue of *Radiological Health Data and Reports* (*1*). Reference should also be made to the February 1968 issue (*2*), in which several changes in the interpretation and reporting of data were introduced.

Table 1. Analytical errors associated with determinations of radionuclide concentrations in a milk sample

Nuclide	Concentration (pCi/liter)	Error [a] (pCi/liter)	Concentration (pCi/liter)	Error [a] (percent of concentration)
Strontium-89	<50	5	≥50	10
Strontium-90	<20	2	≥20	10
Iodine-131	<100	10	≥≥100	10
Cesium-137	<100	10	≥100	10
Barium-140	<100	10	≥100	10

[a] Two standard deviations.

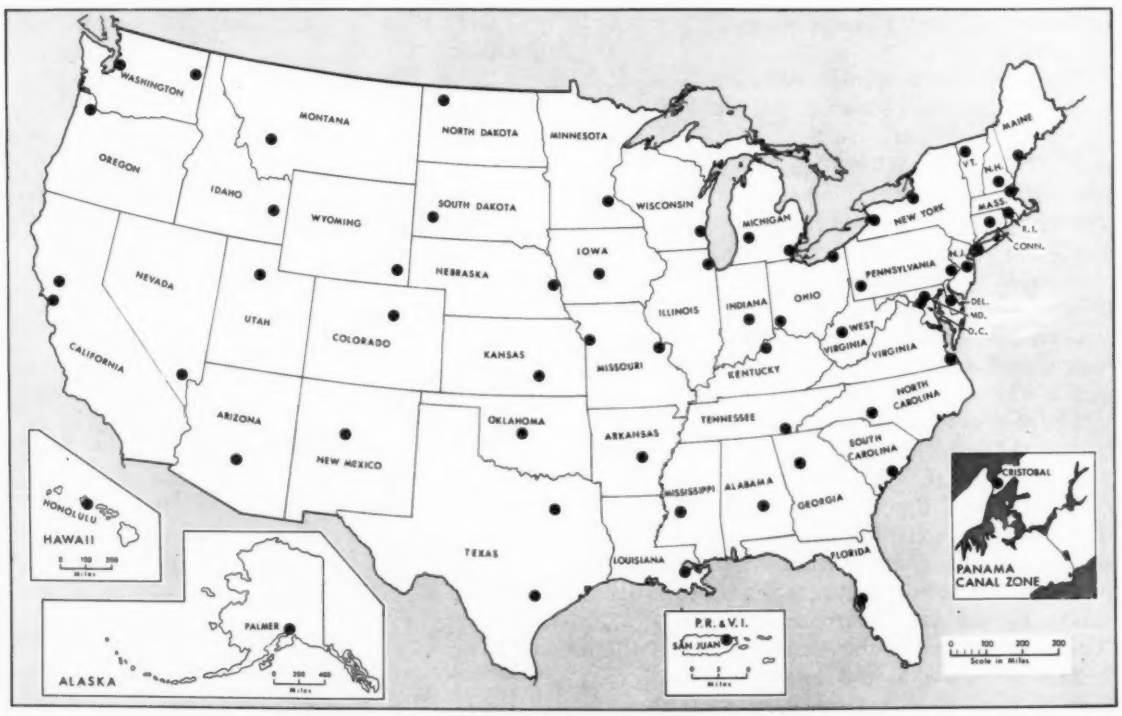

Figure 1. Pasteurized Milk Network sampling stations

Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. Table 2 contains averages for February 1968 and 12-month averages for the period March 1967 through February 1968. The 12-month average enables evaluations of population exposure with respect to the guidance provided by the Federal Radiation Council which suggests average total daily intakes, "averaged over periods of the order of a year," as an appropriate criterion (*3*). The average radionuclide concentrations are based on results obtained from samples collected weekly. Whenever weekly concentrations were less than or equal to the appropriate minimum detectable levels, zero was used for averaging purposes (*2*). At very low radionuclide concentrations this often results in averages lower than the minimum detectable concentration for a single sample, but any positive value reflects at least one weekly sample which was above the minimum detectable level. The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable concentrations in units of pCi/liter are: strontium–89, 5; strontium–90, 2; iodine–131, cesium–137, and barium–140, 10.

The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

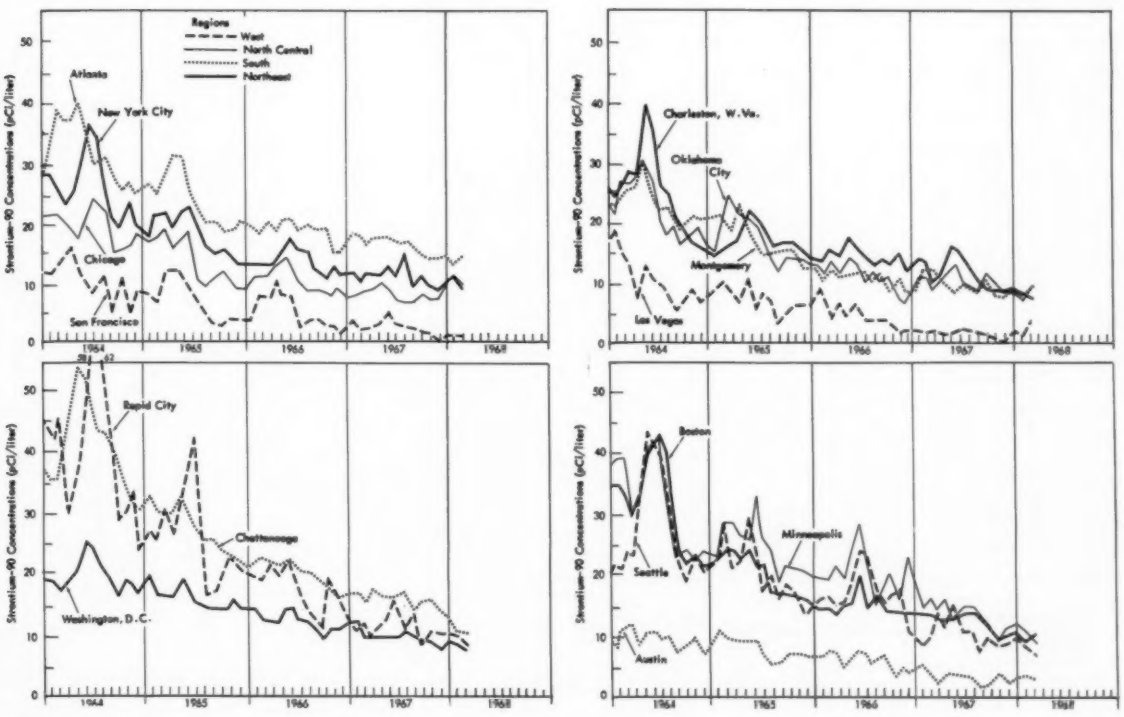

Figure 2. Strontium–90 concentrations in pasteurized milk, 1961–February 1968

Table 2. Average concentrations of radionuclides in milk for February 1968 and the 12-month period, March 1967–February 1968 [a]

Sample location		Radionuclide concentration (pCi/liter)									
		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
		Mar 1967-Feb 1968	Feb 1968	Mar 1967-Feb 1968	Feb 1968	Mar 1967-Feb 1968	Feb 1968	Mar 1967-Feb 1968	Feb 1968	Mar 1967-Feb 1968	Feb 1968
Ala:	Montgomery	0	0	10	10	0	0	14	14	0	0
Alaska:	Palmer	1	4	6	5	0	0	18	6	1	0
Aris:	Phoenix	0	0	2	3	0	0	1	0	0	0
Ark:	Little Rock	0	0	23	21	0	0	19	20	0	0
Calif:	Sacramento	2	0	3	1	0	0	5	5	0	0
	San Francisco	2	0	3	1	0	0	4	10	1	0
C. Z:	Cristobal	0	0	3	2	0	0	18	10	0	0
Colo:	Denver	1	0	6	5	1	0	6	10	0	0
Conn:	Hartford	NA	NA	9	8	0	0	17	13	0	0
Del:	Wilmington	NA	NA	11	8	0	0	12	5	0	0
D. C:	Washington	0	0	10	8	0	0	8	7	0	0
Fla:	Tampa	0	0	8	9	0	0	73	65	0	0
Ga:	Atlanta	0	0	15	14	0	0	23	23	0	0
Hawaii:	Honolulu	0	2	4	2	1	0	8	4	1	0
Idaho:	Idaho Falls	1	2	6	5	0	0	8	0	0	0
Ill:	Chicago	NA	NA	9	9	0	0	13	13	0	0
Ind:	Indianapolis	NA	NA	8	7	0	0	9	14	0	0
Iowa:	Des Moines	1	0	7	7	0	0	7	6	0	0
Kans:	Wichita	1	0	9	9	0	0	4	1	0	0
Ky:	Louisville	0	0	13	10	0	0	7	7	1	0
La:	New Orleans	1	0	24	19	0	0	26	17	0	0
Maine:	Portland	NA	NA	12	10	0	0	33	28	0	0
Md:	Baltimore	0	0	11	8	0	0	9	6	0	0
Mass:	Boston	NA	NA	12	11	0	0	28	22	0	0
Mich:	Detroit	NA	NA	9	8	0	0	14	17	0	0
	Grand Rapids	NA	NA	10	17	0	0	17	14	0	0
Minn:	Minneapolis	1	0	13	10	0	0	13	12	0	3
Miss:	Jackson	1	0	18	17	0	0	15	9	0	0
Mo:	Kansas City	2	1	9	8	0	0	4	15	1	6
	St. Louis	2	3	10	8	0	0	7	10	0	0
Mont:	Helena	1	4	6	4	0	0	8	0	0	0
Nebr:	Omaha	1	5	8	6	0	0	5	5	0	3
Nev:	Las Vegas	0	0	2	4	0	0	3	5	0	0
N. H:	Manchester	NA	NA	14	11	0	0	41	27	0	0
N. J:	Trenton	NA	NA	9	8	0	0	13	12	0	0
N. Mex:	Albuquerque	0	0	2	1	0	0	2	3	0	0
N. Y:	Buffalo	NA	NA	8	7	0	0	13	10	0	0
	New York City	NA	NA	11	8	0	0	15	15	0	0
	Syracuse [b]	NA	NS	7	NS	0	NS	12	NS	0	NS
N. C:	Charlotte	0	0	17	15	1	0	14	2	0	0
N. Dak:	Minot	3	3	13	10	0	0	13	8	0	0
Ohio:	Cincinnati	NA	NA	9	9	0	0	8	5	0	0
	Cleveland	NA	NA	10	8	0	0	12	8	0	0
Okla:	Oklahoma City	0	0	10	10	0	0	5	4	0	0
Ore:	Portland	2	3	8	5	1	0	14	15	0	3
Pa:	Philadelphia	NA	NA	9	9	0	0	11	9	0	0
	Pittsburgh	NA	NA	13	14	0	0	18	14	0	0
P. R:	San Juan	0	0	5	4	0	0	13	9	0	0
R. I:	Providence	NA	NA	11	7	0	0	22	13	0	0
S. C:	Charleston	0	0	15	13	0	0	31	23	0	0
S. Dak:	Rapid City	2	0	11	9	0	0	10	6	0	0
Tenn:	Chattanooga	0	0	15	11	0	0	15	10	0	0
	Memphis	0	0	12	8	0	0	5	9	0	0
Tex:	Austin	0	0	4	4	0	0	4	5	0	0
	Dallas	0	0	9	7	0	0	6	6	0	0
Utah:	Salt Lake City	0	3	6	5	0	0	11	10	0	0
Va:	Norfolk	0	0	10	11	0	0	15	5	0	0
Vt:	Burlington	NA	NA	12	9	0	0	12	11	0	0
Wash:	Seattle	2	0	10	7	0	0	26	15	0	0
	Spokane	1	7	9	7	0	0	15	12	0	0
W. Va:	Charleston	0	0	11	8	0	0	7	0	0	0
Wisc:	Milwaukee	NA	NA	8	8	0	0	14	7	0	0
Wyo:	Laramie	0	0	5	5	0	0	5	7	0	3
Network average		0	1	10	8	0	0	14	10	0	0

[a] See text for averaging procedures.
[b] 12-month averages represent only 9 months data.
NA, no analysis.
NS, no sample.

2. Canadian Milk Network February 1968 [1]

Radiation Protection Division
Department of National Health and Welfare

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the April 1968 issue of *Radiological Health Data and Reports* (*4*).

The February 1968 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 3. Iodine–131 and strontium–89 concentrations were below minimum detectable levels.

Table 3. Stable elements and radionuclides in Canadian whole milk, February 1968

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.13	1.5	9	17
Edmonton	1.13	1.5	8	24
Ft. William	1.07	1.5	13	24
Fredericton	1.08	1.5	18	26
Halifax	1.08	1.5	9	24
Montreal	1.07	1.4	10	22
Ottawa	1.10	1.5	9	24
Quebec	1.08	1.6	13	24
Regina	1.01	1.4	8	14
St. John's, Nfld	1.16	1.5	22	39
Saskatoon	1.11	1.4	7	21
Saulte Ste. Marie	1.04	1.4	15	30
Toronto	1.16	1.5	5	21
Vancouver	1.17	1.6	13	40
Windsor	1.12	1.4	5	18
Winnipeg	1.13	1.5	7	29

[1] Prepared from March 1968 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

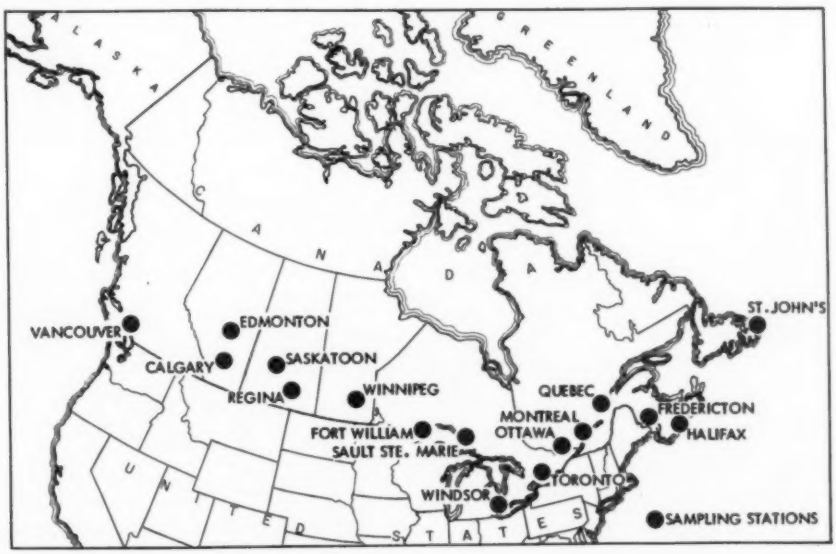

Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program February 1968

Pan American Health Organization and *U.S. Public Health Service*

The Pan American Health Organization (PAHO) in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (*5*).

Figure 4. Pan American Milk Sampling Program stations

Table 4 presents stable potassium, strontium–90 and cesium–137 monthly concentrations for February 1968.

Table 4. Stable elements and radionuclide concentrations in Pan American milk,[a] February 1968

Sampling stations	Number of samples	Potassium (g/liter)	Strontium-90 [b] (pCi/liter)	Cesium-137 [b] (pCi/liter)
Chile: Santiago	1	1.7	0	0
Colombia: Bogota	1	1.3	0	20
Ecuador: Guayaquil	1	1.6	0	0
Jamaica: Mandeville	1	1.4	0	75
Venezuela: Caracas	1	1.4	3	0
Canal Zone: Cristobal [c]	5	1.6	2	10
Puerto Rico: San Juan [c]	6	1.6	4	9

[a] Strontium-89 analyses was ≤5 pCi/liter, and iodine-131 and barium-140 were ≤10 pCi/liter for all samples.
[b] Single sample analyses for strontium-90 was ≤2 pCi/liter and cesium-137 ≤10 pCi/liter and are reported as 0.
[c] For comparison, the radionuclide concentrations in Pasteurized Milk Network samples collected at Cristobal, Canal Zone, and San Juan, Puerto Rico, are presented.

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State Milk Surveillance Activities

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States now have comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

Figure 1 shows the States which report milk surveillance activities in *Radiological Health Data and Reports*. States having programs appearing in this issue are highlighted in the figure. Following is a summary of previously covered State programs, their reporting period, and issue of appearance.

State milk network	Period reported	Last presented
Colorado	October–December 1967	April 1968
Connecticut	October–December 1967	May 1968
Florida	October–December 1967	April 1968
Indiana	October–December 1967	May 1968
Iowa	October–December 1967	May 1968
Michigan	October–December 1967	May 1968
Minnesota	October–December 1967	May 1968
New York	October–December 1967	May 1968
Oklahoma	October–December 1967	April 1968
Pennsylvania	October–December 1967	May 1968
Tennessee	October–December 1967	April 1968
Texas	October–December 1967	April 1968

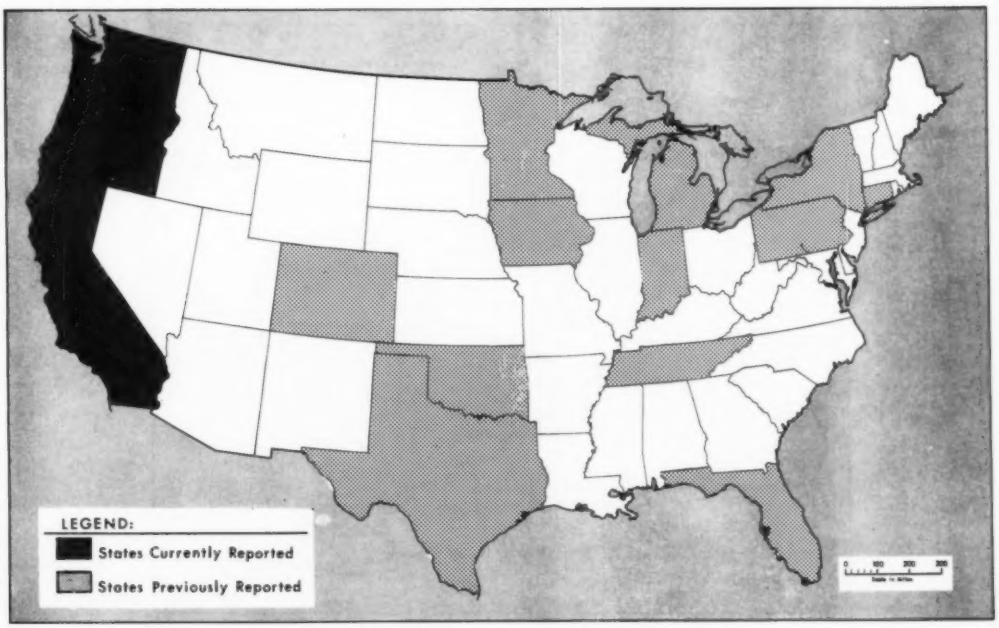

Figure 1. Reported State milk programs

1. California Milk Network October–December 1967

Division of Environmental Sanitation
State of California
Department of Public Health

Surveillance of specific radionuclides in milk is one phase of the California Department of Health program on radiation control. This milk monitoring function is conducted by the Department's Bureau of Radiological Health at 10 major milksheds (figure 2).

In January 1960, the eight original sampling locations were chosen by the State Department of Agriculture so as to be representative of milk consumed by a high percentage of the State's population. The Del Norte and Mendocino milksheds were added to the program in March 1962 and since that time, weekly, biweekly or monthly sampling of pasteurized milk has been conducted in 10 milkshed areas of the State. A description of the various California milksheds was presented earlier by Heslep and Cornish (*1*).

Strontium–89 and strontium–90 concentrations are determined radiochemically. Potassium–40, iodine–131, cesium–137, and barium–140 in whole fluid milk are determined by gamma-scintillation spectrometry. A detailed description of the analytical procedures was presented in an earlier report (*2*).

The monthly calcium, potassium, and radionuclide concentrations in California pasteurized milk are given in table 1 for the period of October to December 1967.

Network average strontium–90 and cesium–137 concentrations are presented graphically in figure 3.

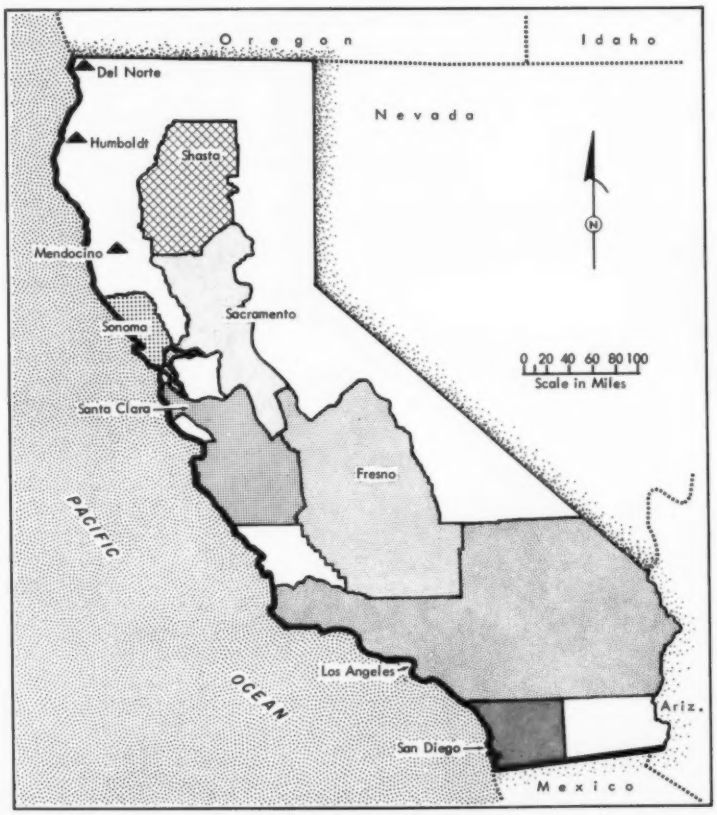

Figure 2. California milksheds

Table 1. Stable elements and radionuclide concentrations in California milk October–December 1967

Sampling location	Calcium (g/liter)			Potassium (g/liter)			Strontium-89 (pCi/liter)			Strontium-90 (pCi/liter)		
	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec
Del Norte	1.35	1.06	1.29	1.3	1.5	1.5	5	ND	*5	18	14	16
Fresno	1.20	NA	1.13	1.6	1.5	1.5	ND	NA	ND	ND	NA	2
Humboldt	1.20	1.15	1.00	1.4	1.4	1.4	ND	ND	*3	4	3	4
Los Angeles	1.07	1.13	1.02	1.6	1.6	1.7	ND	ND	ND	ND	ND	ND
Mendocino	1.21	1.16	1.18	1.6	1.7	1.6	ND	ND	ND	2	2	3
Sacramento	1.24	1.21	1.02	1.4	1.5	NA	4	ND	ND	ND	2	3
San Diego	1.13	1.12	1.15	1.5	1.5	1.5	*4	ND	ND	ND	ND	ND
Santa Clara	1.11	1.27	1.10	1.5	1.5	1.5	5	ND	ND	ND	ND	ND
Shasta	1.14	1.15	1.20	1.4	1.8	1.6	ND	ND	ND	2	2	3
Sonoma	1.17	1.28	1.14	1.4	1.6	1.6	ND	ND	ND	2	3	3

Sampling location	Cesium-137 (pCi/liter)			Iodine-131 (pCi/liter)			Barium-140 (pCi/liter)		
	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec
Del Norte	20	13	50	ND	ND	22	ND	ND	15
Fresno	7	ND	11	ND	ND	ND	ND	ND	ND
Humboldt	*7	11	9	ND	ND	ND	ND	ND	ND
Los Angeles	10	12	ND	ND	ND	ND	ND	ND	ND
Mendocino	ND	*9	ND	ND	ND	ND	ND	ND	ND
Sacramento	10	11	NA	ND	ND	NA	ND	ND	NA
San Diego	ND	ND	ND	ND	ND	ND	ND	ND	ND
Santa Clara	ND	12	13	ND	ND	ND	ND	ND	ND
Shasta	9	10	12	ND	ND	ND	ND	ND	ND
Sonoma	12	*9	11	ND	ND	ND	ND	ND	ND

* When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant.

NA, no analysis performed.
NS, no sample collected.
ND, nondetectable.
Minimum detectable levels:
Strontium-89—2.5 pCi/liter
Strontium-90—1.5 pCi/liter
Iodine-131—7 pCi/liter
Cesium-137—7 pCi/liter
Barium-140—7 pCi/liter

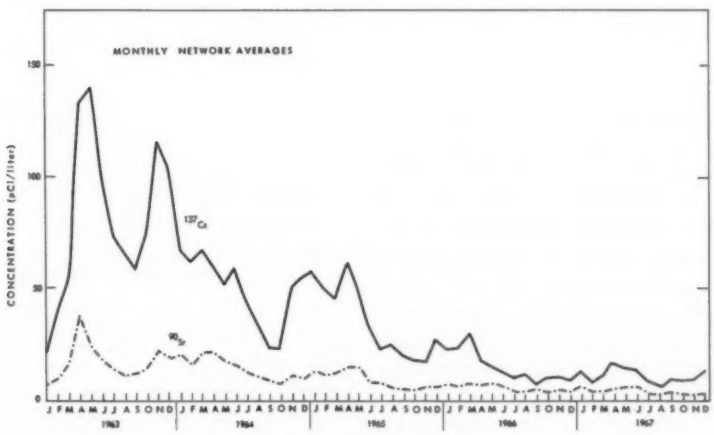
MONTHLY NETWORK AVERAGES
CONCENTRATION (pCi/liter)
137Cs
90Sr
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1963
1964
1965
1966
1967

Figure 3. Radionuclide concentrations in California milk 1964–December 1967

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
April–June 1967	December 1967
July–September 1967	March 1968

2. Oregon Milk Network October–December 1967

Division of Sanitation and Engineering
Oregon State Board of Health

The Oregon State Board of Health has monitored radionuclide concentrations in milk since March 1962. As part of this program routine milk samples are collected at seven major production areas (figure 4), which supply 90 percent of the milk distributed in Oregon.

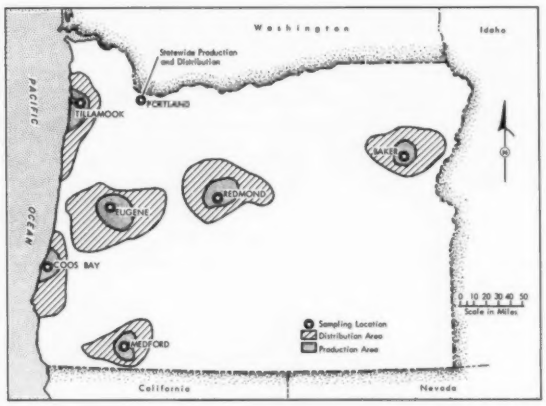

Figure 4. Oregon milk production and distribution areas

Currently, pasteurized milk samples are collected monthly by the Oregon Department of Agriculture, except in the Portland area where weekly samples are collected by the city of Portland. The milk sampling frequency is accelerated to a weekly basis in areas where iodine–131 concentrations exceed 100 pCi/liter, or when cesium–137 concentrations exceed 500 pCi/liter. Strontium–90 analyses are performed on a bimonthly basis, but may be done monthly when significant increases are observed.

Strontium–90 concentrations are determined using an ion-exchange analytical procedure (*3*). Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma scintillation spectrometry (*4*).

Table 2 gives the strontium–90 and cesium–137 concentrations in pasteurized milk from October through December 1967. These data

Table 2. Radionuclide concentrations in Oregon pasteurized milk, October–December 1967

Location	Sampling frequency	Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
		Oct	Nov	Dec	Oct	Nov	Dec
Baker	M	NA	9	NA	NA	16	<15
Coos Bay	M	NA	9	NA	NA	22	<15
Eugene	M	NA	4	NA	NA	<15	<15
Medford	M	NA	6	NA	NA	<15	20
Portland composite	W	NA	4	NA	<15	16	17
Portland local	W	NA	NA	NA	NA	17	16
Redmond	M	NA	4	NA	NA	16	18
Tillamook	M	NA	NA	NA	NA	<15	NS

Key to symbols: M, sampled monthly.
W, sampled weekly.
NA, no analysis.
NS, no sample.

are presented graphically in figure 5. Iodine–131 and barium–140 concentrations remained below minimum detectable levels of 15 pCi/liter for all samples which were collected in October through December 1967.

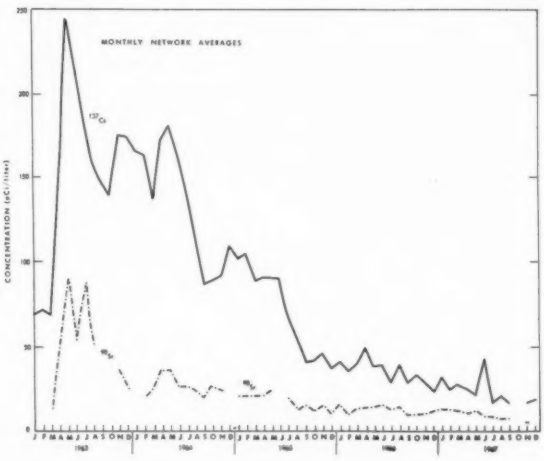
MONTHLY NETWORK AVERAGES
^{137}Cs
^{90}Sr
^{131}I
CONCENTRATION (pCi/liter)
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1963
1964
1965
1966
1967

Figure 5. Radionuclide concentrations in Oregon milk network, 1963–December 1967

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
April–June 1967	December 1967
July–September 1967	March 1968

3. Washington Milk Network October–December 1967

Air Quality and Radiation Control Section
State of Washington Department of Health

The Washington State Department of Health initiated a surveillance program for radioactivity in raw milk in December 1962. The collection points shown in figure 6 were selected to provide samples representative of varying climatological conditions within the State's two major milksheds. In addition to the eight milk sampling locations in Washington, milk is sampled from Northwest Idaho (Sandpoint), as this area forms a part of the Spokane milkshed. Details of the sampling procedures were presented in an earlier report (*5*).

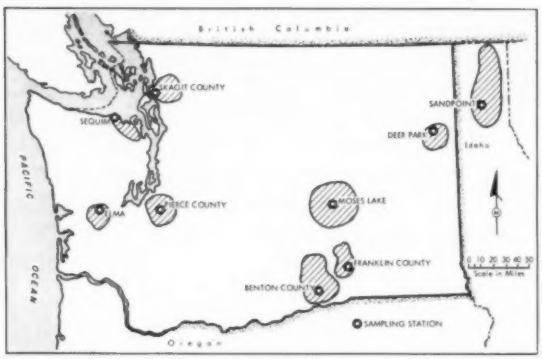

Figure 6. Washington milksheds and sampling locations

Selected samples are radiochemically analyzed for strontium–90. Potassium–40, iodine–131, cesium–137, and barium–140 concentrations are determined by gamma scintillation spectrometry. Details of the analytical procedures were presented earlier (*5*).

Table 3 presents the monthly potassium and radionuclide concentrations in Washington raw milk for October through December 1967. Samples collected during October through December 1967 contained less than 10 pCi/liter of iodine–131. Barium–140 results remained below 15 pCi/liter for all samples collected during this period. Monthly average strontium–90 and cesium–137 concentrations are presented graphically in figure 7 to display general trends.

Table 3. Stable element and radionuclide concentrations in Washington raw milk, October–December 1967

Sampling location	Potassium (g/liter)			Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec
Benton County	NS	1.5	NS	NS	<1	NS	NS	<15	NS
Deer Park	1.4	1.5	1.5	5	4	3	<15	<15	<15
Elma	1.5	1.5	1.6	4	3	3	<15	25	24
Franklin County	1.5	NS	1.5	1	NS	2	<15	NS	<15
Moses Lake	1.5	1.5	1.5	3	<1	3	<15	<15	<15
Pierce County	1.6	1.5	1.5	2	3	2	<15	<15	<15
Sandpoint	1.6	1.4	1.5	9	4	9	28	23	17
Sequim	1.5	1.6	1.5	4	2	1	15	<15	<15
Skagit County	1.5	1.5	1.5	3	4	6	18	16	21

NS, no sample collected.

During this reporting period, three samples were collected (one from Benton County and two from Franklin County) and analyzed for zinc–65. In all three cases, zinc–65 levels were less than 26 pCi/liter. Milk samples produced in areas using Columbia River water for irrigation have periodically been found to contain this radionuclide.

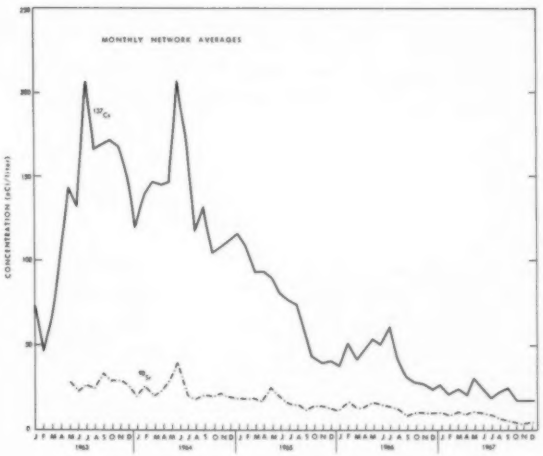
MONTHLY NETWORK AVERAGES
CONCENTRATION (pCi/liter)
^{137}Cs
^{90}Sr
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1963
1964
1965
1966
1967

Figure 7. Radionuclide concentrations in Washington milk, 1963–December 1967

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
April–June 1967	December 1967
July–September 1967	March 1967

REFERENCES

(*1*) HESLEP, J. M. and A. C. CORNISH. California milk network and milkshed comparisons, April–June 1963. Radiol Health Data 4:596–599 (December 1963).

(*2*) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH. California milk network, 1960–June 1962. Radiol Health Data 4:90–92 (February 1963).

(*3*) PORTER, C. R., M. W. CARTER, B. KAHN, and E. W. PEPPER. Rapid Field Method for the Collection of Radionuclides from Milk. Proceedings of the First International Congress of the International Radiation Protection Association held in Rome, Italy, September 5–10, 1966 (in press).

(*4*) OREGON STATE BOARD OF HEALTH, DIVISION OF SANITATION AND ENGINEERING. Oregon milk network, April–June 1965. Radiol Health Data 6:683–684 (December 1965).

(*5*) STATE OF WASHINGTON DEPARTMENT OF HEALTH, AIR AND RADIATION CONTROL SECTION. Washington milk network, January–June 1965. Radiol Health Data 6:619–621 (November 1965).

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Periodically, results from the United Kingdom Diet Survey, conducted by the United Kingdom Agricultural Research Council Radiobiological Laboratory, are presented for comparison with data observed in the United States. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows.

Program	Period reported	Last presented
California Diet Study	July–December 1967	May 1968
Connecticut Standard Diet	January–June 1967	November 1967
Institutional Diet, PHS	July–September 1967	April 1968

1. Strontium–90 in Tri-City Diets April–December 1967 [1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium–90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 18 food categories are purchased at each of these 3 cities every 3 months on a staggered basis (*i.e.*, New York City, May, August and November 1967; San Francisco, June, September, and December 1967; and Chicago, April, July, and October 1967) and are analyzed for strontium–90. Consumption figures used are based upon data from the Department of Agriculture (*1*). Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general.

[1] Data from Fallout Program Quarterly Summary Report, HASL–193. Available from the Clearinghouse for Federal Scientific & Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

The consumption data are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is boned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the waste.

After two samplings at each city, it was found that the calcuim content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses of dietary components were performed for the third time recently, and further confirmed this result (*2*). Calcium analyses were therefore discontinued and the average calcium content of foods was computed and used to estimate the average annual intake of this material. Details of the sampling system and a discussion of the results obtained have been summarized (*3*).

Results of the April–June samplings are presented in table 1; July–September in table 2, and October–December 1967 in table 3. The variation with time of the daily intake of strontium–90 in the three cities is plotted in

Table 1. Average dietary consumption and strontium–90 intake in Tri-City diet April–June 1967

Food category	Diet (kg/yr)	Calcium (g/yr)	Chicago-April 1967		New York-May 1967		San Francisco-June 1967	
			(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)
Milk	221	234.5	9.5	2,100	10.4	2,298	4.4	972
Fresh fruit	68	12.9	2.6	177	11.8	802	2.6	177
Fresh vegetables	43	15.3	13.1	563	33.7	1,449	4.2	181
Root vegetables	17	6.3	9.0	153	19.1	325	7.6	129
Potatoes	45	4.9	6.6	297	9.8	441	1.7	77
Macaroni	3	0.6	8.1	24	3.9	12	6.5	20
Rice	3	1.0	1.8	5	1.9	6	2.4	7
Fruit juices	19	1.7	4.8	91	7.1	135	4.4	84
Canned vegetables	20	4.2	15.4	308	6.8	136	4.7	94
Canned fruit	26	1.3	2.1	55	1.5	39	1.8	47
Dried beans	3	3.1	31.7	9	8.7	26	30.7	92
Flour	43	8.6	8.5	366	8.8	378	4.5	194
Bakery products	37	39.2	3.6	133	8.2	303	12.0	444
Whole grain products	11	10.1	12.5	138	19.6	216	21.3	234
Meat, fish, poultry, eggs	115	38.8	----------	[a] 233	----------	[a] 346	----------	[a] 145
Annual intake		383		4,652		6,912		2,897
Daily intake (pCi/day)				12.7		18.9		7.9
pCi strontium-90/g Ca				12		18		7.6

[a] Estimated as 5 percent of total intake.

Table 2. Average dietary consumption and strontium–90 intake in Tri-City diet July–September 1967

Food category	Diet (kg/yr)	Calcium (g/yr)	Chicago-July 1967		New York-August 1967		San Francisco-September 1967	
			(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)
Milk	221	234.5	6.2	1,370	12.9	2,851	2.1	464
Fresh fruit	68	12.9	4.6	313	5.3	360	1.9	129
Fresh vegetables	43	15.3	----------	[a] 528	15.7	675	2.8	120
Root vegetables	17	6.3	5.1	87	30.0	510	6.7	114
Potatoes	45	4.9	----------	[a] 455	12.1	545	2.3	104
Macaroni	3	0.6	5.9	18	6.4	19	5.0	15
Rice	3	1.0	2.9	9	1.8	5	1.9	6
Fruit juices	19	1.7	3.8	72	6.0	114	3.0	57
Canned vegetables	20	4.2	7.4	148	9.3	186	5.2	104
Canned fruit	26	1.3	1.2	31	1.5	39	0.6	16
Dried beans	3	3.1	13.7	41	62.5	188	10.4	31
Flour	43	8.6	13.0	559	11.4	490	3.0	129
Bakery products	37	39.2	16.1	596	----------	[a] 230	3.5	130
Whole grain products	11	10.1	39.9	439	----------	[a] 169	8.8	97
Meat, fish, poultry, eggs	115	38.8	----------	[b] 246	----------	[b] 341	----------	[b] 79
Annual intake		383		4,912		6,822		1,595
Daily intake (pCi/day)				13.5		18.7		4.4
pCi strontium-90/g Ca				13		18		4.2

[a] Estimated from other sampling dates.

[b] Estimated as 5 percent of total intake.

Table 3. Average dietary consumption and strontium–90 intake in Tri-City diet October–December 1967

Food category	Diet (kg/yr)	Calcium (g/yr)	Chicago-October 1967		New York-November		San Francisco-December	
			(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)
Milk	221	234.5	6.0	1,326	8.3	1,834	1.6	354
Fresh fruit	68	12.9	3.7	252	13.7	932	1.2	82
Fresh vegetables	43	15.3	6.1	262	38.5	1,656	4.5	194
Root vegetables	17	6.3	8.1	138	9.8	167	2.1	36
Potatoes	45	4.9	----------	[a] 455	9.3	419	2.9	131
Macaroni	3	0.6	5.1	15	5.1	15	3.0	9
Rice	3	1.0	1.9	6	3.7	11	1.5	5
Fruit juices	19	1.7	3.2	61	3.2	61	1.6	30
Canned vegetables	20	4.2	13.2	264	10.1	202	2.4	48
Canned fruit	26	1.3	2.1	55	1.0	26	1.0	26
Dried beans	3	3.1	12.5	38	28.6	86	16.9	51
Flour	43	8.6	8.8	378	14.0	602	3.1	133
Bakery products	37	39.2	9.1	337	5.2	192	2.8	104
Whole grain products	11	10.1	14.4	158	15.6	172	3.6	40
Meat, fish, poultry, eggs	115	38.8	----------	[b] 197	----------	[b] 336	----------	[b] 65
Annual intake		383		3,942		6,711		1,308
Daily intake (pCi/day)				10.8		18.4		3.6
pCi strontium-90/g Ca				10		18		3.4

[a] Estimated from other sampling dates.
[b] Estimated as 5 percent of total intake.

figure 1. A discussion of cesium–137 intakes as reflected in the Tri-City Diet Study has been presented previously (4).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
May–July 1966	June 1967
August–December 1966	September 1967
January–March 1967	March 1968

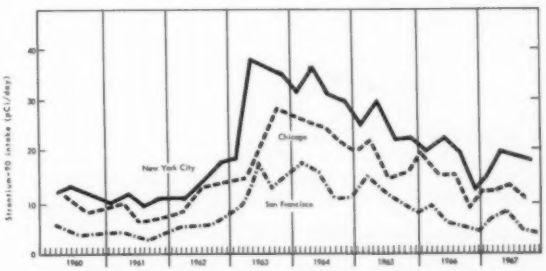

Figure 1. Daily intake of strontium–90 in Tri-City diet March 1960–December 1967

REFERENCES

(*1*) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, household food consumption survey, Report No. 1 (1955). Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (December 1956).

(*2*) U.S. ATOMIC ENERGY COMMISSION. Fallout program quarterly summary reports HASL–144: 281–287. Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (April 1, 1964). Summarized in Radiol Health Data 5:285–288 (June 1964).

(*3*) RIVERA, J., and J. H. HARLEY. HASL contributions to the study of fallout in food chains, HASL–147. Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (July 1, 1964).

(*4*) U.S. ATOMIC ENERGY COMMISSION. Cesium–137 in Tri-City diets, 1965. Radiol Health Data Rep 8:154–157 (March 1967).

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence [1] of strontium–90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium–90, respectively.

Water sampling program	Period reported	Last presented
Colorado River Basin	1965–1966	May 1968
Coast Guard	January–December 1966	November 1967
Minnesota Municipal	January–June 1967	January 1968
New York Surface	January–May 1967	January 1968
Washington Surface	July 1965–June 1966	August 1967

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States, December 1967

Division of Pollution Surveillance, Federal Water Pollution Control Administration Department of Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium–90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the August 1967 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assess-

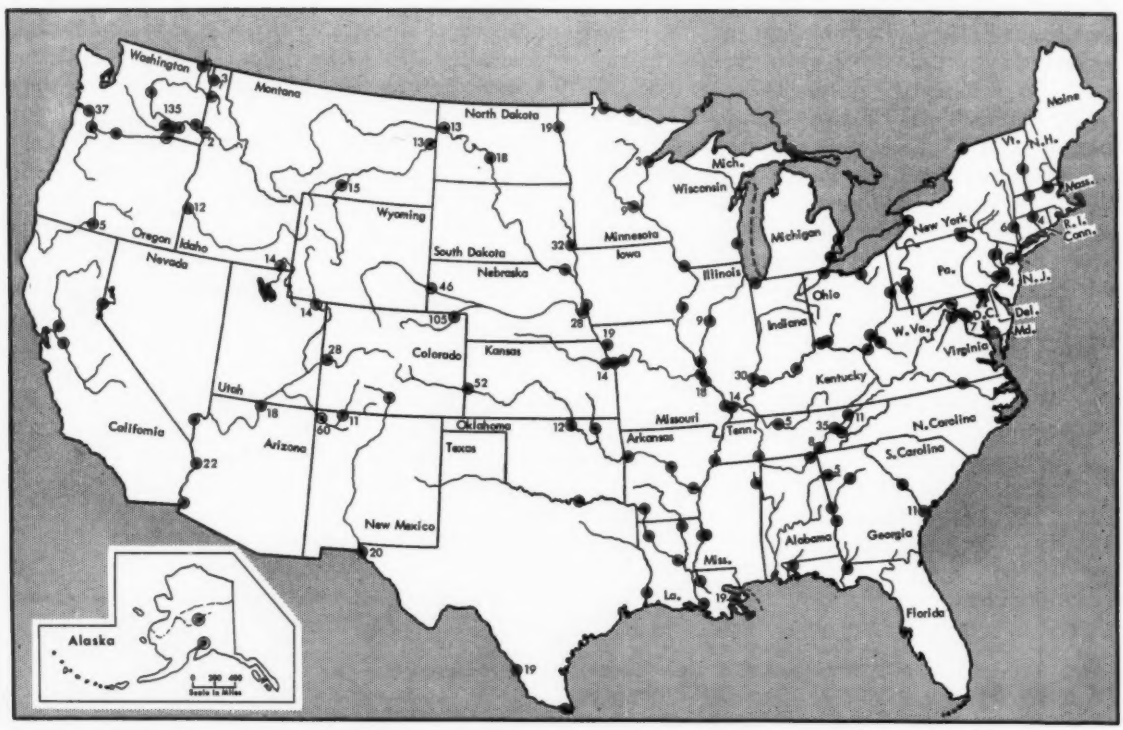

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, December 1967

Table 1. Radioactivity in raw surface waters, December 1967

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	0	<1	<1	3	8	11
Arkansas River:						
Coolidge, Kans.	<1	31	31	5	47	52
Ponca City, Okla.	0	5	5	0	12	12
Bear River:						
Preston, Idaho	0	3	3	1	13	14
Big Horn River:						
Hardin, Mont.	0	6	6	1	14	15
Big Sioux River:						
Sioux Falls, S. Dak.	0	3	3	2	30	32
Clearwater River:						
Lewiston, Idaho	<1	0	<1	1	1	2
Clinch River:						
Clinton, Tenn.	2	0	2	7	4	11
Kingston, Tenn.*	0	0	0	5	30	35
Colorado River:						
Loma, Colo.	3	4	7	14	14	28
Page, Ariz.	0	4	4	0	18	18
Parker Dam, Calif.-Ariz.	0	5	5	1	21	22
Columbia River:						
Pasco, Wash.*	0	<1	<1	10	125	135
Clatskanie, Ore.	0	0	0	9	28	37
Connecticut River:						
Enfield Dam, Conn.	0	0	0	1	3	4
Coosa River:						
Rome, Ga.	1	0	1	3	2	5
Cumberland River:						
Cheatham Lock, Tenn.	0	0	0	1	4	5
Delaware River:						
Philadelphia, Pa.	0	0	0	0	4	4
Great Lakes:						
Duluth, Minn.	0	1	1	1	2	3
Green River:						
Dutch John, Utah	0	2	2	0	14	14
Hudson River:						
Poughkeepsie, N. Y.	0	0	0	1	5	6
Illinois River:						
Peoria, Ill.	0	1	1	1	8	9
Kansas River:						
DeSoto, Kans.	0	2	2	1	13	14
Klamath River:						
Keno, Ore.	0	0	0	1	4	5
Mississippi River:						
St. Paul, Minn.	0	1	1	0	9	9
E. St. Louis, Ill.	3	1	4	10	8	18
New Orleans, La.	2	1	3	11	8	19
Missouri River:						
Williston, N. Dak.	1	6	7	0	13	13
Bismarck, N. Dak.	1	2	3	5	13	18
St. Joseph, Mo.	1	3	4	3	16	19
North Platte River:						
Henry, Nebr.	1	23	24	5	41	46
Ohio River:						
Cairo, Ill.	4	0	4	8	6	14
Pend Oreille River:						
Albeni Falls Dam, Idaho	0	<1	<1	<1	3	3
Platte River:						
Plattsmouth, Nebr.	2	4	6	10	18	28
Potomac River:						
Washington, D. C.	1	1	2	3	4	7
Rainy River:						
Baudette, Minn.	0	0	0	0	7	7
Red River, North:						
Grand Forks, N. Dak.	0	0	0	1	18	19
Rio Grande:						
El Paso, Tex.	1	10	11	1	19	20
Laredo, Tex.	2	3	5	9	10	19
San Juan River:						
Shiprock, N. Mex.	13	3	16	40	20	60
Savannah River:						
Port Wentworth, Ga.*	0	0	0	3	8	11
Snake River:						
Payette, Idaho	0	3	3	1	11	12
South Platte River:						
Julesburg, Colo.	6	46	52	19	86	105
Tennessee River:						
Chattanooga, Tenn.	1	0	1	4	4	8
Wabash River:						
New Harmony, Ind.	7	0	7	23	7	30
Yellowstone River:						
Sidney, Mont.	0	8	8	2	11	13
Maximum	13	46	52	40	125	135
Minimum	0	0	0	0	1	2

* Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

ment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations of the Water Pollution Surveillance System for 1961 through 1965 has been presented (*7*). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During November and December 1967, the following stations showed values in excess of 15 pCi/liter on alpha radioactivity for dissolved solids:

Arkansas River; Coolidge, Kans.
North Platte River; Henry, Nebr.
South Platte River; Julesburg, Colo.

During December, Pasco, Wash., on the Columbia River showed a decrease in the value to less than 150 pCi/liter on beta radioactivity for dissolved solids.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*2*) *Ibid.*, 1959 Edition.
(*3*) *Ibid.*, 1960 Edition.
(*4*) *Ibid.*, 1961 Edition.
(*5*) *Ibid.*, 1962 Edition.
(*6*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*7*) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961–1965. Radiol Health Data Rep 9:1–15 (January 1968).

Radioactivity In California Waters, January–June 1967[1]

Bureau of Radiological Health,
State of California, Department of Public Health

Gross beta radioactivity in California domestic waters is monitored by the State of California's Bureau of Radiological Health. The importance of this program in the State's environmental surveillance activities stems from the fact that most of California's domestic water supplies are of surface origin.

Radioactivity in such water supplies consists of the natural radioactivity in surface streams, radioactivity added by the discharge of sewage or by industrial waste effluents, and radioactivity from fallout, particularly fallout into open terminal or distribution reservoirs. Present efforts consist of sampling raw and treated surface waters and well waters. It should be noted that except for large metropolitan water supplies, raw water sampling is being phased out and treated water sampling being substituted or continued. This procedural change is predicated upon sampling water at the point of consumption.

[1] Data from July and October 1967 issues of Radiological Health News, State of California Department of Public Health, Bureau of Radiological Health, 2151 Berkeley Way, Berkeley, Calif. 94704.

Figure 1. California surface water sampling stations

Most of the supplies sampled have, as a source, raw surface waters (figure 1), although a few wells, along with some water supplies that use infiltration galleries, are also sampled.

Monitoring of domestic water supplies is on a continuing basis, since it has not been possible to forecast levels of radioactivity in these supplies based upon levels in rain, snow, or surface streams. Under the present sampling schedule, monthly 500 ml samples are collected and the total solids analyzed for alpha and beta radioactivity. In addition, 3-liter samples are

Table 1. Gross beta radioactivity in California domestic waters, January–June 1967

Sampling station	Quality	Concentration (pCi/liter)					
		January	February	March	April	May	June
Alturas	Well	69	[a] 10	[a] 12	[a] 17	[a] 31	NS
Antioch	Treated	ND	[a] 12	[a] 5	[a] 2	ND	ND
Berkeley	Treated	ND	[a] 3	ND	[a] 2	[a] 1	[a] 4
Clearlake Highlands	Treated	[a] 2	[a] 2	ND	ND	[a] 2	ND
Crescent City	Well	[a] 11	[a] 4	[a] 10	79	[a] 11	[a] 2
Death Valley	Treated	[a] 13	[a] 16	41	[a] 13	[a] 15	[a] 14
Dos Palos	Treated	[a] 17	[a] 4	[a] 27	[a] 22	[a] 6	NS
Eureka	Raw	[a] 14	[a] 12	ND	[a] 3	[a] 11	[a] 5
	Treated	ND	[a] 5	10	[a] 5	ND	ND
Fort Bragg	Treated	NS	NS	NS	NS	[a] 14	ND
Lake Arrowhead	Treated	[a] 15	[a] 8	[a] 3	[a] 8	NS	NS
Lake Millerton	Raw	[a] 19	[a] 9	[a] 15	[a] 4	[a] 6	[a] 7
Los Angeles Laboratory	Raw	[a] 17	[a] 12	NS	[a] 19	NS	NS
Marin Municipal Water District	Treated	ND	[a] 4	[a] 6	ND	[a] 3	[a] 6
Mariposa	Treated	NS	[a] 5	NS	[a] 18	ND	NS
Metropolitan Water District of Southern California:							
Lake Havasu	Raw	[a] 11	ND	[a] 26	[a] 21	[a] 15	NS
Weymouth Plant	Treated	[a] 24	70	[a] 24	67	[a] 7	[a] 34
Monterey	Treated	[a] 15	[a] 16	ND	NS	[a] 4	[a] 11
Napa	Treated	5	ND	ND	[a] 18	ND	[a] 13
Needles	Well	[a] 37	[a] 24	[a] 19	NS	[a] 9	[a] 9
North Marin Water District	Treated	[a] 9	NS	[a] 5	[a] 1	[a] 3	[a] 3
	Raw	[a] 4	[a] 12	[a] 9	[a] 13	[a] 14	[a] 8
	Sludge [b]	132	NS	118	[a] 30	[a] 40	ND
Oroville:							
Wyandotte Irrigation District	Treated	[a] 6	[a] 10	[a] 15	[a] 17	ND	[a] 6
Pleasanton	Well	ND	[a] 12	[a] 2	ND	ND	[a] 2
Redding	Treated	ND	[a] 9	ND	ND	ND	ND
Sacramento							
American River	Treated	NS	[a] 5	NS	[a] 13	[a] 5	[a] 1
Sacramento River	Treated	NS	[a] 14	NS	5	[a] 3	ND
San Diego	Raw	[a] 12	[a] 9	33	[a] 15	[a] 24	ND
	Treated	[a] 7	[a] 23	[a] 11	[a] 1	[a] 19	[a] 15
San Francisco:							
Water Department	Raw	[a] 13	54	ND	[a] 3	[a] 11	ND
Alameda, East	Raw	[a] 5	[a] 4	NS	[a] 8	[a] 5	NS
Brightside Weir	Raw	ND	[a] 3	[a] 9	[a] 11	75	NS
Calaveras Reservoir	Raw	ND	[a] 16	[a] 6	[a] 1	[a] 15	NS
Crystal Springs	Raw	[a] 11	[a] 9	NS	ND	[a] 14	NS
Hetch Hetchy	Raw	[a] 13	[a] 8	[a] 23	[a] 15	ND	[a] 8
San Jose	Raw	ND	NS	ND	[a] 6	[a] 9	ND
Santa Barbara	Treated	ND	ND	ND	[a] 11	ND	ND
Santa Cruz	Raw	NS	NS	NS	NS	NS	[a] 6
	Treated	NS	NS	NS	NS	NS	[a] 6
Santa Rosa	Raw	ND	ND	[a] 5	[a] 14	ND	ND
Scotia	Treated	NS	NS	[a] 9	[a] 3	[a] 1	[a] 7
Tahoe City	Raw	NS	[a] 8	NS	[a] 3	[a] 3	[a] 6
Ukiah	Well	[a] 4	NS	NS	[a] 15	ND	ND
Vallejo:							
Fleming Hill	Raw	[a] 4	[a] 11	[a] 14	[a] 4	[a] 2	[a] 4
	Treated	ND	[a] 7	ND	[a] 4	[a] 13	[a] 10
Swansy Reservoir	Treated	[a] 3	ND	ND	[a] 12	[a] 10	ND
Yosemite	Treated	[a] 7	[a] 8	ND	[a] 5	[a] 3	[a] 6
Maximum		132	70	118	79	75	34
Minimum		2	2	2	1	1	1

[a] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best estimate, but is not statistically significant.

[b] Sludge reported in pCi/g (dry weight).

NS, no sample collected.

ND, no detectable radioactivity.

collected monthly for approximately 6 months and composited for specific radionuclide analysis on a semiannual basis.

Analytical procedures

Radionuclide analyses of water are carried out in the State's Sanitation and Radiation Laboratory. Measurements of alpha and alpha-plus-beta radioactivities are made with a low-background windowless gas-flow proportional counter. Counting methods used follow those recommended by the U.S. Public Health Service (*1*).

Individual samples are evaporated to dryness and the residue ashed at 450°C. The ashed sample is dissolved and transferred to an aluminum planchet for beta-particle counting. Specific radionuclides are determined semiannually on composite samples. Gamma-ray emitting nuclides are determined by gamma-ray spectroscopy and radium and radiostrontium by chemical separation and counting.

Discussion

Table 1 shows the monthly average beta radioactivity in the suspended-plus-dissolved solids in surface water supplies in California

Table 2. Radionuclide concentrations in California surface water, 1966–1967

Sampling station and date	Concentration (pCi/liter)						
	Radium-226	Cerium-141-144	Cesium-137	Zirconium-niobium-95	Strontium-90	Strontium-89	Potassium-40
Antioch:							
August-December 1966	0.03	ND	ND	ND	1	ND	3
Berkeley:							
June-December 1966	*0.02	ND	ND	ND	1	ND	2
Death Valley							
July-December 1966	*0.08	*1	*1	*1	1	ND	15
Dos Palos:							
September 1966-March 1967	NA	ND	ND	ND	ND	*1	*2
Eureka:							
January-June 1965 [b]	0.04	*1	ND	ND	ND	*1	*1
June-December 1965 [b]	0.03	ND	*1	ND	ND	ND	ND
January-June 1966	*0.01	ND	ND	ND	ND	*1	*1
July-December 1966	*0.02	*1	ND	ND	ND	ND	ND
Lake Millerton:							
July-December 1966	*0.02	ND	ND	ND	1	ND	ND
November 1966-March 1967	*0.01	ND	ND	ND	1	ND	*2
Metropolitan Water District of Southern California:							
Weymouth Plant:							
July-December 1966	NA	ND	ND	ND	*1	ND	*4
Monterey:							
September 1966-February 1967	0.11	ND	ND	ND	ND	2	3
Napa:							
August-December 1966	NA	ND	ND	ND	*1	*1	*4
Needles:							
August-December 1966	*0.06	ND	ND	ND	ND	ND	7
North Marin Water District:							
July-December 1966	ND	ND	ND	ND	1	NA	*4
Oroville:							
December 1966-April 1967	NA	ND	ND	ND	ND	1	*1
Redding:							
July-December 1966	*0.01	ND	ND	ND	ND	ND	*1
San Diego:							
June-December 1966	*0.12	ND	ND	ND	2	ND	5
San Francisco:							
January-November 1966	*0.01	ND	ND	*2	NS	NS	*1
San Jose:							
July-December 1966	0.03	ND	ND	ND	ND	ND	*2
Santa Barbara:							
September 1966-February 1967	NA	ND	ND	ND	ND	ND	2
Santa Cruz:							
July-December 1966	NA	ND	ND	ND	NS	NS	*2
Santa Rosa:							
September 1966-February 1967	0.03	ND	ND	*1	ND	ND	*3
Tahoe City:							
July-December 1966	*0.01	ND	ND	*1	ND	ND	*1
Vallejo:							
July-December 1966	*0.02	ND	ND	ND	1	1	2
Willets:							
July 1966-January 1967	0.04	ND	1	1	ND	ND	3
Yosemite:							
November 1966-March 1967	*0.02	ND	ND	ND	1	ND	ND

Results for manganese-54 for all stations were nondetectable during this period except for a value of *1 pCi/liter at Eureka for January-June 1965 and July-December 1965.

[a] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate but is not statistically significant.

[b] Data not previously reported.

NA, no analysis.

ND, no detectable radioactivity.

NS, no sample.

from January through June 1967. Following treatment, these waters are used for industrial and domestic purposes. Because alpha radioactivity in water has, in general, been undetectable or very slight, alpha radioactivity analyses are not presented. No increase in radioactivity level of surface water has been observed.

Table 2 shows specific radionuclide concentrations in California surface waters for 1965 through April 1967 by stations.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1966	June 1967
July–December 1966	February 1968

REFERENCE

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclide analyses of environmental samples, R 59–6. Radiological Health Research Activities, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio 45226 (November 16, 1959).

Radiostrontium In Tap Water, July–December 1967[1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Health and Safety Laboratory has performed analyses for strontium–90 in tap water at New York City since August 1954. Samples of tap water are collected daily so that by the end of the month a composite of at least 100 liters is available for analysis. Cesium–137 determinations were begun in January 1964. The analytical methods used at the laboratory are given in the Health and Safety Laboratory Manual of Standard Procedures (*1*).

Strontium–90 concentration and cesium–137/strontium–90 ratios in New York City tap water for July through December 1967 are presented in table 1. These results appear graphically in figure 1.

A decreasing trend has been observed in the strontium–90 concentrations since the July 1963 peak. The maximum strontium–90 concentrations observed are below the acceptable limit as set forth in the interstate carrier drinking water standards (*2*).

[1] Prepared from information appearing in Fallout Program Quarterly Summary Report, HASL–193. This report is available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

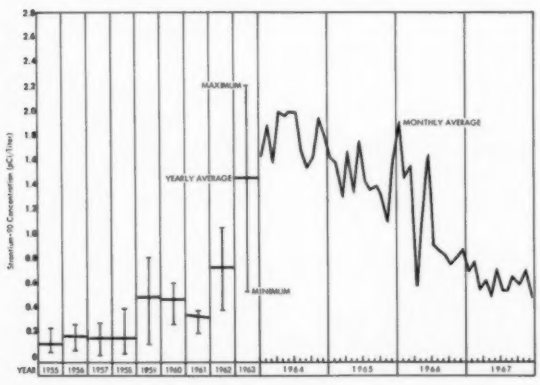

Figure 1. Strontium–90 concentrations in New York City tap water, 1955–December 1967

Table 1. Radiostrontium in New York City tap water July–December 1967

Date 1967	Strontium-90 * (pCi/liter)	Cesium-137/ strontium-90
July	0.55	0.09
August	.55	.09
September	.61	.06
October	.58	.10
November	.68	.15
December	.45	.13

* Approximately 100 liters per sample.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1967	April 1968

REFERENCES

(*1*) U.S. ATOMIC ENERGY COMMISSION. Manual of standard procedures 40:E–38–01–16. Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York 14, N.Y.

(*2*) FEDERAL REGISTER RULES AND REGULATIONS. Title 42–Public Health, Chapter 1, Public Health Service, Department of Health, Education and Welfare; Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards 27:2154–2155. Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (March 6, 1962).

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-particle analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data.* In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
HASL Fallout Network	January–June 1967	March 1968
HASL 80th Meridian Network	Calendar Year 1965	January 1967
Plutonium in Airborne Particulates	April–June 1967	November 1967

1. Radiation Alert Network February 1968

National Center for Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection when most of the radon daughter products have decayed and at 29 hours after collection when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate National Center for Radiological Health officials by mail or telephone, depending on levels found. Compilation of the daily field estimates is reported elsewhere on a monthly basis (*1*). A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique during February 1968. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, February 1968

Station location		Number of samples		Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation			
								Total depth (mm)	Field estimation of deposition		
		Air	Pptn	Maximum	Minimum	Average [a]			Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	29	3	6.83	0.73	2.03	Nov 67	46	0	0	
Alaska:	Adak	[b]					Apr 68	[c]			
	Anchorage	19	6	1.29	.00	.12	Dec 67	25	[d]	[d]	[d]
	Attu Island	[b]					May 68	[c]			
	Fairbanks	[b]					Jan 68	[c]			
	Juneau	18	11	.38	.00	.08	Feb 68	51	11	151	0
	Kodiak	19		1.29	.00	.31	Mar 68	[c]			
	Nome	2		.00	.00	.00	Sept 67	[c]			
	Pt. Barrow	29		1.25	.55	1.04	June 68	[c]			
	St. Paul Island	27		.87	.42	.47	Oct 67	[c]			
Ariz:	Phoenix	17		14.60	.96	4.86	Feb 68	[c]			
Ark:	Little Rock	14	6	1.92	.29	.84	Dec 67	26	0	0	
Calif:	Berkeley	19	6	.74	.00	.22	Mar 68	75	6	75	0
	Los Angeles	19	3	2.73	.49	.96	Sept 67	12	3	12	0
C. Z:	Ancon	15		3.12	.96	1.90	Mar 68	[c]			
Colo:	Denver	18	4	5.81	.56	1.74	Mar 68	9	[d]	[d]	[d]
Conn:	Hartford	18	2	1.07	.19	.31	Jan 68	17	2	17	0
Del:	Dover	11		1.71	.25	.64	Nov 67	[c]			
D. C:	Washington	23	1	1.54	.27	.86	June 68	10	1	10	0
Fla:	Jacksonville	21	7	1.21	.35	.62	Dec 67	88	6	74	0
	Miami	17	4	.96	.24	.43	Jan 68	66	4	66	0
Ga:	Atlanta	19		2.02	.81	1.22	Oct 67	[c]			
Guam:	Agana	20		1.04	.00	.38	Nov 67	[c]			
Hawaii:	Honolulu	29	1	.91	.30	.65	May 68	22	[d]	[d]	[d]
Idaho:	Boise	21	6	3.28	.34	1.64	May 68	56	6	56	0
Ill:	Springfield	19	3	3.83	.35	1.25	June 68	41	0	0	
Ind:	Indianapolis	19	3	1.76	.54	.85	Oct 67	41	3	41	31
Iowa:	Iowa City	20		1.62	.00	1.06	Mar 68	[c]			
Kans:	Topeka	21	4	3.01	.45	1.12	Dec 67	20	4	20	14
Ky:	Frankfort	10		1.51	.50	.81	June 68	[c]			
La:	New Orleans	17	5	1.25	.23	.59	June 68	97	[d]	[d]	[d]
Maine:	Augusta	20	3	.79	.00	.23	Feb 68	13	4	13	4
Md:	Baltimore	19	1	4.07	.26	.99	Jan 68	10	1	10	11
	Rockville	[b]					May 68	[c]			
Mass:	Lawrence	20	1	1.51	.00	.43	Nov 67	11	0	0	
	Winchester	19	2	1.23	.00	.18	Apr 68	6	2	6	0
Mich:	Lansing	20		1.42	.35	.69	May 68	[c]			
Minn:	Minneapolis	18	1	.24	.14	.22	Nov 67	2	1	2	2
Miss:	Jackson	9	2	1.14	.35	.65	Feb 68	37	2	37	0
	Jefferson City	19	3	1.45	.19	.70	Oct 67	15	3	15	0
Mont:	Helena	19	3	1.89	.16	.55	Apr 68	4	3	4	6
Nebr:	Lincoln	19	1	3.86	.98	1.90	Oct 67	2	1	2	0
Nev:	Las Vegas	16		3.61	1.08	2.27	Jan 68	[c]			
N. H:	Concord	20		.98	.00	.45	June 68	[c]			
N. J:	Trenton	19	1	2.83	.20	.64	Feb 68	4	1	4	0
N. Mex:	Sante Fe	20	5	1.03	.21	.56	Apr 68	21	3	21	3
N. Y:	Albany	20	1	2.70	.23	.58	Oct 67	4	1	4	1
	Buffalo	17		.74	.00	.27	Mar 68	[c]			
	New York	18		.66	.05	.42	Apr 68	[c]			
N. C:	Gastonia	17	1	18.40	1.43	5.39	Mar 68	14	[d]	[d]	[d]
N. Dak:	Bismarck	19	1	.59	.00	.36	June 68	2	0	0	
Ohio:	Cincinnati	17		3.71	.40	1.27	Nov 67	[c]			
	Columbus	18	2	2.59	.00	.69	Feb 68	7	1	2	0
	Painesville	19	6	.89	.21	.35	Jan 68	11	6	11	4
Okla:	Oklahoma City	14	1	3.02	.33	.96	May 68	4	1	4	0
	Ponca City	22	2	8.95	.00	1.33	Jan 68	10	2	10	0
Ore:	Portland	18	7	.86	.00	.34	Oct 67	70	7	70	0
Pa:	Harrisburg	17		4.65	.40	1.08	Oct 67	[c]			
P. R:	San Juan	[b]					Feb 68	[c]			
R. I:	Providence	17	1	.37	.00	.26	May 68	25	0	0	
S. C:	Columbia	8	2	.57	.27	.43	Apr 68	7	0	0	
S. Dak:	Pierre	17		4.91	.46	1.88	Feb 68	[c]			
Tenn:	Nashville	15	5	1.51	.30	.71	May 68	11	4	10	0
Tex:	Austin	20	6	6.41	.77	2.58	Nov 67	43	[d]	[d]	[d]
	El Paso	21	5	6.03	.84	2.57	June 68	30	5	30	0
Utah:	Salt Lake City	29	10	.81	.23	.46	Sept 67	57	0	0	
Vt:	Barre	19	4	.73	.00	.28	Dec 67	13	4	13	0
Va:	Richmond	14	2	.89	.38	.63	Dec 67	11	0	0	
Wash:	Seattle	6	9	.95	.00	.42	Dec 67	89	[d]	[d]	[d]
	Spokane	19	3	2.52	.47	1.10	Nov 67	13	0	0	
W. Va:	Charleston	19	3	2.10	.24	.78	Apr 68	7	3	7	1
Wisc:	Madison	14	3	.55	.12	.33	Dec 67	12	3	12	15
Wyo:	Cheyenne	19	3	6.38	.78	1.84	Jan 67	9	3	9	10
Network summary		1,240	175	18.40	0.00	0.95		28	3	19	2

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples showing no field estimate are ignored).
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.

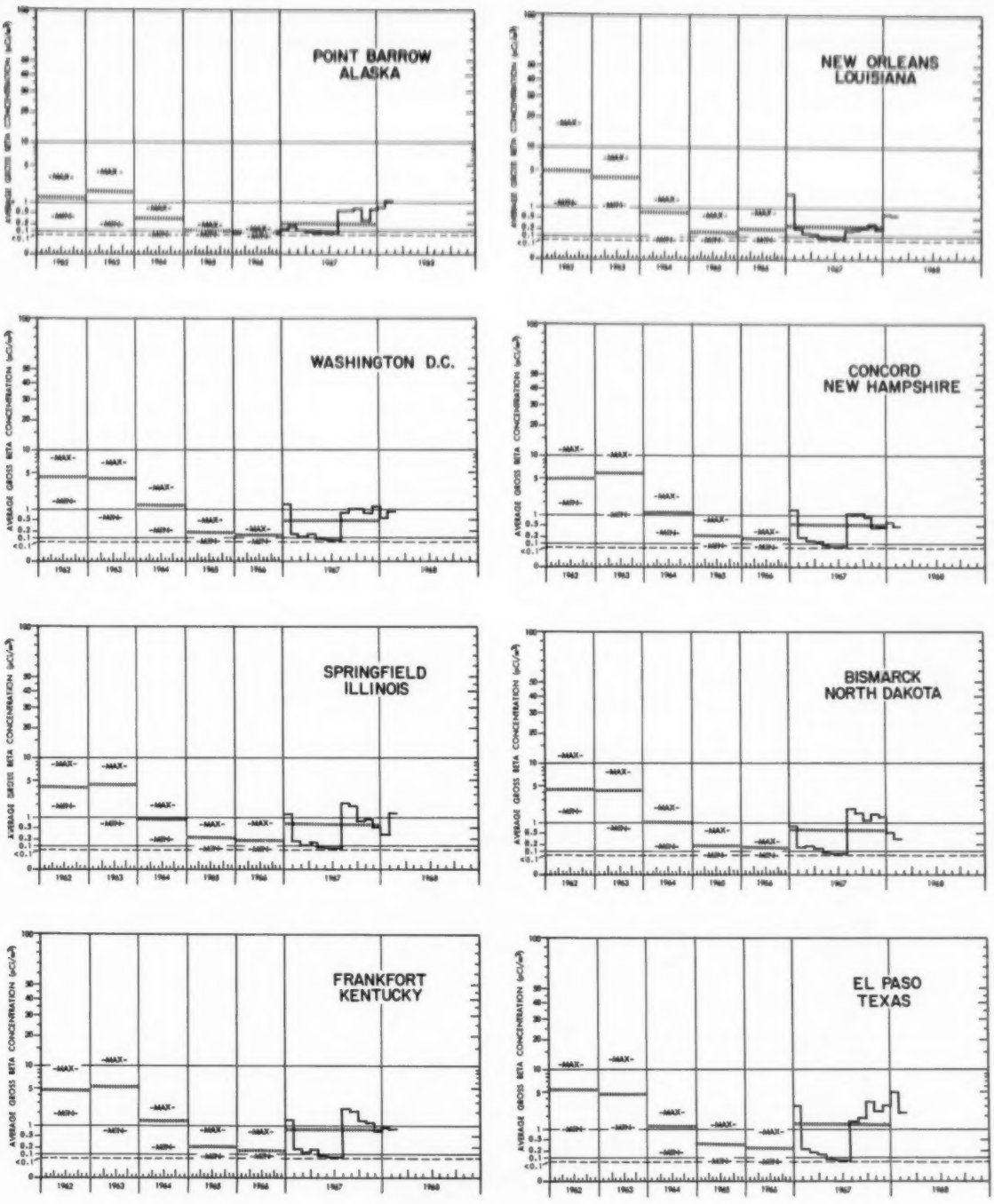

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1962–February 1968

2. Canadian Air and Precipitation Monitoring Program, February 1968 [1]

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

A summary of the sampling procedures and methods of analysis was presented in the April 1968 issue of *Radiological Health Data and Reports*.

[1] Prepared from information and data in the March 1968 monthly report "Data from Radiation Protection Program" Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for February 1968 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, February 1968

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m²)
Calgary	29	0.6	0.0	0.3	285	0.7
Coral Harbour	29	.2	.0	.1	93	2.6
Edmonton	29	.4	.0	.2	271	.8
Ft. Churchill	29	.2	.0	.1	25	.5
Ft. William	23	.3	.0	.2	130	.8
Fredericton	28	.3	.0	.1	48	1.6
Goose Bay	29	.2	.0	.1	32	3.1
Halifax	29	.3	.0	.1	44	3.4
Inuvik	29	.3	.0	.1	80	1.3
Montreal	29	.4	.1	.2	39	1.5
Moosonee	29	.2	.0	.1	14	.2
Ottawa	29	.4	.1	.1	45	1.4
Quebec	29	.2	.0	.1	65	2.7
Regina	27	.3	.0	.2	249	1.3
Resolute	28	.2	.0	.1	15	.3
St. John's, Nfld	29	.3	.0	.1	13	2.1
Saskatoon	29	.3	.0	.1	186	.5
Sault Ste Marie	25	.4	.1	.2	21	1.7
Toronto	29	.2	.0	.2	44	1.6
Vancouver	29	.3	.0	.1	70	7.3
Whitehorse	29	.3	.0	.1	217	1.0
Windsor	29	.2	.0	.1	24	1.1
Winnipeg	29	.2	.0	.1	274	1.3
Yellowknife	29	.2	.0	.1	35	.3
Network summary	28	0.6	0.0	0.1	97	1.6

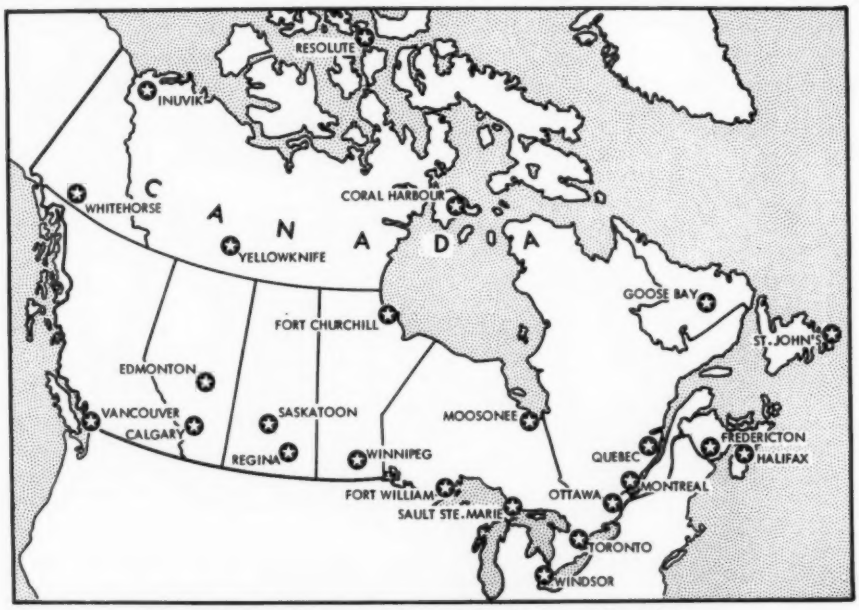

Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program
February 1968

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), Mexico, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of México, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potósi; and Ensenada. Staff members of the DRS operate the station at México D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6 by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month were needed to get a reliable average radioactivity at each station (*7*).

The maximum, minimum, and average beta radioactivity in surface air during February 1968 are presented in table 3.

Figure 4. Mexican air sampling locations

Table 3. Mexican gross beta radioactivity of airborne particulates, February 1968

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	11	0.3	0.1	0.1
Chihuahua	13	.9	.1	.4
Ciudad Juárez	7	.8	.3	.5
Ensenada	3	.5	.4	
Guadalajara	NS			
Guaymas	NS			
La Paz	NS			
Matamoros	NS			
Mazatlán	10	.3	.2	.3
Mérida	NS			
México, D. F.	8	1.0	.1	.4
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	3	.1	.1	
Torreón	5	.4	.2	.3
Veracruz	5	.7	.1	.4

NS, no sample, station temporarily shutdown.

4. Pan American Air Sampling Program February 1968

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the January 1968 *Radiological Health Data and Reports*. The February 1968 air monitoring results from the participating countries are given in table 4.

Table 4. Summary of gross beta radioactivity in Pan American surface air, February 1968

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	6	0.03	0.02	0.03
Bolivia: La Paz	16	.02	.00	.01
Chile: Santiago	9	.03	.01	.02
Colombia: Bogota	21	.10	.02	.05
Ecuador: Guayaquil	18	.05	.02	.03
Jamaica: Kingston	18	.36	.04	.15
Peru: Lima	16	.05	.01	.02
Venezuela: Caracas	13	.13	.03	.07
West Indies: Trinidad	19	.21	.03	.10
Pan American summary	136	0.36	0.00	0.06

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

Figure 5. Pan American Air Sampling Program stations

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Radionuclides In Alaska Caribou and Reindeer, August–October 1967

National Center for Radiological Health
U.S. Public Health Service

Under a cooperative agreement between the Alaskan Department of Health and Welfare, the Alaskan Department of Fish and Game, and the U.S. Public Health Service, an active program of caribou and reindeer sampling and analysis was undertaken in 1963 to aid in the assessment of radionuclide intake of Alaskan residents. This joint sampling activity was continued based on the results of a limited sampling effort conducted by these groups in 1962.

Through the second quarter of 1964, the sampling was confined to the three principal caribou herds and one privately-owned reindeer herd. This program was expanded in September 1964, when the sampling of additional privately owned and government-owned reindeer herds was begun through the assistance of the Fish and Wildlife Service and the Bureau of Indian Affairs, Department of Interior.

Figure 1 shows the locations of the principal caribou and reindeer herds in Alaska. The code indicates the herds that were sampled during the fall of 1967.

For the present program, samples are taken in the spring and fall from selected caribou and reindeer herds. Samples of muscle and rumen contents of five animals from each herd are collected during the sampling period. Hock joint bones from five animals are collected only from the Nome herd during the fall collection period. Muscle samples are analyzed individually and rumen content samples from each herd are composited before analysis for cesium–137 by gamma-ray spectroscopy. Muscle and bone samples from the individual herd are composited before analysis of strontium–89 and strontium–90. All samples are analyzed at the Public Health Service's Southwestern Radiological Health Laboratory in Las Vegas, Nev.

Strontium–89, strontium–90, and cesium–137 data are presented in table 1 for caribou muscle, reindeer muscle and rumen contents for the August–October 1967 collection period. The muscle data are of prime interest, since muscle is an important constituent of the diet for many Alaskan residents. A comparison of the muscle data is shown in table 2.

The cesium–137 concentrations in muscle in the fall of 1967 have decreased considerably as compared to the fall of 1966. The only exception is the Shishmaref reindeer herd. This may be due to the fact that the 1966 sample was collected in July rather than during October as in 1967. The cesium–137 concentrations in the summer are usually quite low compared to concentrations in the fall. A summary of the strontium–90 and cesium–137 concentrations in foodstuffs in Alaska (including reindeer and caribou meat) is contained in the December 1966 issue of *Radiological Health Data and Reports.*

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–November 1966	May 1967
March–May 1967	January 1968

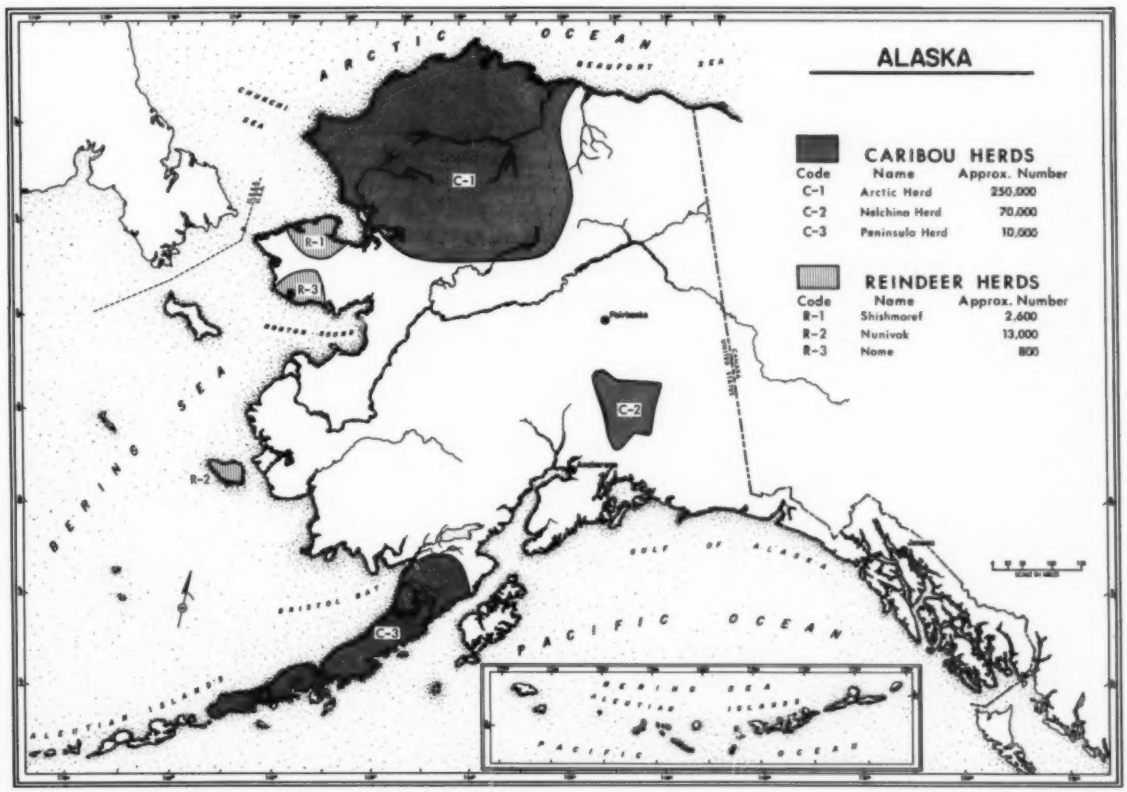

Figure 1. Location of caribou and reindeer herds in Alaska

Table 1. Radionuclide concentrations in muscle and rumen of Alaska caribou and reindeer August–October 1967

Herd and sampling location [a]	Collection date, 1967	Sex	Age (years)	Muscle (pCi/kg wet weight)			Rumen (pCi/kg wet weight)
				^{89}Sr [b]	^{90}Sr [b]	^{137}Cs	^{137}Cs
Arctic caribou herd, Anatuvak Pass, C-1	10/14	F	5	4	33	5.0×10^3	4.8×10^3
	10/16	M	9			6.5×10^3	
	10/16	M	2			8.1×10^3	
	10/16	F	9			4.9×10^3	
	10/16	F	4			4.8×10^3	
Nelchina caribou herd, Dickey Lake, C-2	9/16	F	Calf	5	10	9.9×10^3	6.2×10^3
	9/16	F	3			2.9×10^3	
	9/16	F	4			3.4×10^3	
	9/20	F	9			5.3×10^3	
	9/20	F	Calf			7.4×10^3	
Peninsula caribou herd, King Salmon, C-3	10/4	F	2	35	66	10.2×10^3	8.1×10^3
	10/4	F	2			14.6×10^3	
	10/4	M	4			11.7×10^3	
	10/4	M	3			6.6×10^3	
	10/4	F	Calf			13.0×10^3	
Shishmaref reindeer herd, Seward Peninsula, R-4	10/31	M	5	5	53	11.0×10^3	4.6×10^3
	10/31	M	4			13.5×10^3	
	10/31	M	4			11.0×10^3	
	10/31	M	4			8.9×10^3	
	10/31	M	4			8.5×10^3	
Nunivak Island reindeer herd, R-8	8/24	F	3	16	18	3.7×10^3	1.7×10^3
	8/24	M	2			3.0×10^3	
	8/24	F	2			3.9×10^3	
	8/24	F	3			3.0×10^3	
	8/24	F	2			3.9×10^3	
Nome reindeer herd, R-10	8/31	F	— [c]	93	177	13.9×10^3	9.4×10^3
	9/1	F	—			13.5×10^3	
	9/1	F	—			11.7×10^3	
	9/1	F	2			25.8×10^3	
	8/31	F	—			9.0×10^3	
	8/31	F	—			11.0×10^3	

[a] Sampling locations are shown in figure 1.
[b] Composite of individual samples taken within the herd.
[c] Ages not available.

Table 2. Cesium–137 concentrations in caribou and reindeer muscles, fall 1966–1967

Herd	Average cesium-137 concentration (pCi/kg wet weight)	
	1966	1967
Arctic caribou	17.0×10^3 (October)	5.9×10^3 (October)
Nelchina caribou	13.0×10^3 (November)	5.8×10^3 (September)
Peninsula caribou	20.0×10^3 (November)	11.2×10^3 (October)
Shishmaref reindeer	3.6×10^3 (July)	10.6×10^3 (October)
Nunivak reindeer	6.7×10^3 (August)	3.5×10^3 (August)
Nome reindeer	25.0×10^3 (November)	14.2×10^3 (September)

Strontium–90 in Human Bone, January–March 1967[1]

National Center for Radiological Health
Public Health Service

To obtain data on the concentration of strontium–90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. Analyses of selected samples of people in older age groups have shown their bone strontium–90 content to be low and age-independent (*1*). Consequently, the target population includes children and young adults up to 25 years of age.

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age.

Most specimens received to date have been vertebrae and ribs. Efforts to collect long bones for comparison of results with British data have not been successful.

[1] Period during which death or surgical procedure occurred.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory of the National Center for Radiological Health, at Winchester, Mass. Sample collection and preparation are explained elsewhere (*2*). Strontium–90 is measured by tributyl phosphate extraction of its yttrium daughter, which is precipitated as an oxalate. The stronium–90 content is then calculated (*3*) from the yttrium–90 radioac-

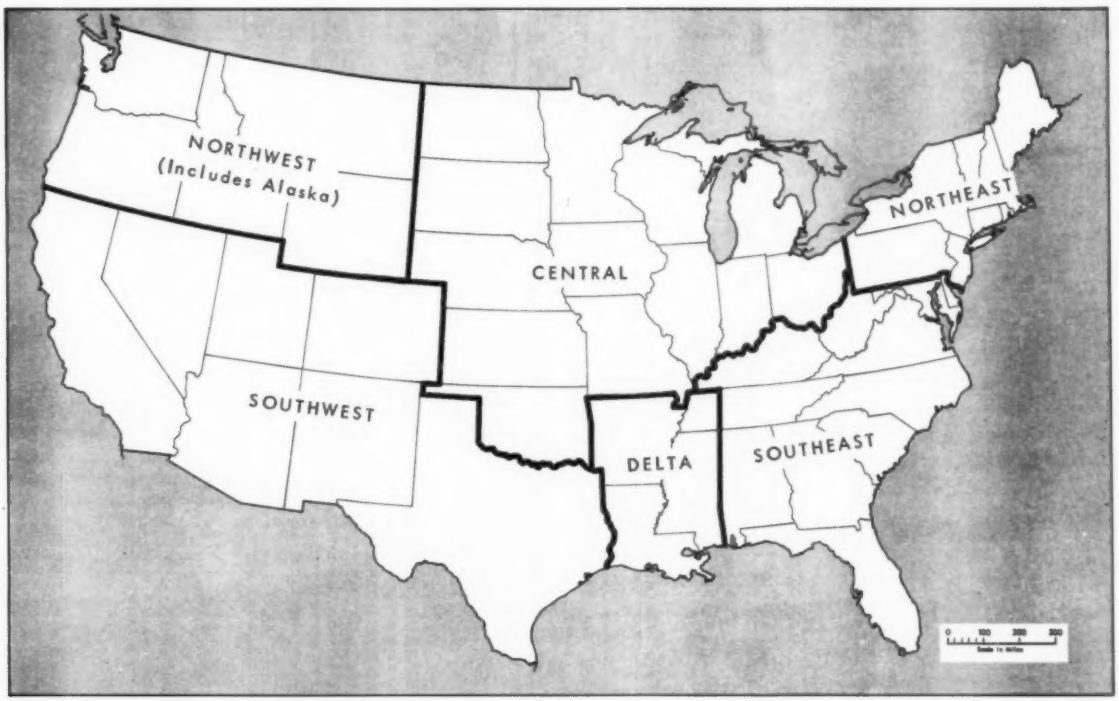

Figure 1. Geographical regions for human bone sampling

Table 1. Strontium-90 in human bone, January–March 1967

Bone region and State of residence	Bone type [a]	Age [b] (years)	Sex	Strontium-90 concentration (pCi/kg bone)	Calcium concentration (g/kg bone)	$^{90}Sr/Ca$ (pCi/g)
Northeast:						
N. Y.	V, R	0	F	59.0 ± 8.7	[c]48.7	1.21
N. Y.	V, R, F	0	M	31.9 ± 4.9	30.0	1.06
N. Y.	V	1	M	79.9 ± 15.0	28.8	2.77
Mass.	V	2	F	178.0 ± 14.0	30.4	5.85
Conn.	V	2	F	79.9 ± 11.0	26.4	3.02
Vt.	V	2	F	140.0 ± 5.7	34.5	4.05
N. Y.	V	2	F	173.0 ± 17.0	30.8	5.61
Mass.	V	3	F	135.0 ± 13.0	28.9	4.67
Mass.	V	3	M	150.0 ± 13.0	36.1	4.15
Mass.	V	3	M	113.0 ± 14.0	32.4	3.48
N. Y.	V	3	M	119.0 ± 13.0	33.2	3.58
N. Y.	V	3	F	92.9 ± 14.0	30.5	3.04
Mass.	V	4	M	63.9 ± 11.0	26.1	2.44
Mass.	V	4	M	283.0 ± 18.0	42.2	6.70
Mass.	V	5	M	62.9 ± 9.3	26.6	2.36
Vt.	V	5	M	190.0 ± 15.0	39.8	4.77
N. Y.	V	5	M	48.0 ± 6.7	27.9	1.72
N. Y.	V	5	M	56.2 ± 9.3	20.1	2.79
N. Y.	V	5	M	72.2 ± 12.0	35.1	2.05
Mass.	V	6	M	117.0 ± 10.0	33.5	3.49
R. I.	V	6	F	121.0 ± 14.0	33.1	3.65
Mass.	V	6	M	154.0 ± 14.0	32.4	4.75
Mass.	V	6	M	69.3 ± 8.7	29.1	2.38
Vt.	V	6	F	118.0 ± 10.0	37.8	3.12
N. Y.	V	6	F	81.7 ± 9.9	36.8	2.22
Mass.	V	8	F	134.0 ± 11.0	37.7	3.55
N. Y.	V	8	M	106.0 ± 13.0	39.0	2.71
N. H.	V	9	M	82.1 ± 8.2	32.1	2.55
Maine	V	10	M	92.9 ± 8.4	32.1	2.89
Mass.	V	10	M	82.0 ± 8.1	33.4	2.45
Vt.	V	10	F	20.2 ± 5.7	43.4	0.46
N. Y.	V	10	F	84.5 ± 11.0	30.8	2.74
N. Y.	V	10	F	72.4 ± 9.0	35.2	2.05
N. Y.	V	10	F	159.0 ± 12.0	47.3	3.36
Mass.	V	11	F	128.0 ± 8.5	42.5	3.01
Mass.	V	11	M	66.3 ± 10.0	35.5	1.86
Vt.	V	12	F	229.0 ± 22.0	50.6	4.52
Conn.	V, R	12	F	101.0 ± 10.0	33.8	2.98
Mass.	V	13	F	62.4 ± 13.0	28.3	2.20
Pa.	V	13	M	39.4 ± 8.5	27.7	1.42
Maine	V	14	M	88.9 ± 8.5	34.4	2.58
Vt.	V	14	F	212.0 ± 11.0	53.9	3.93
N. Y.	V	15	M	209.0 ± 13.0	61.9	3.37
N. H.	V	16	F	157.0 ± 10.0	52.8	2.97
N. Y.	V	16	M	184.0 ± 14.0	59.2	3.10
Vt.	V	18	M	152.0 ± 12.0	53.8	2.82
N. Y.	V	18	F	80.4 ± 11.0	43.7	1.83
Conn.	V, R	18	M	133.0 ± 11.0	45.0	2.95
Conn.	V	18	M	206.0 ± 12.0	82.7	2.49
Vt.	V	19	F	97.1 ± 11.0	56.3	1.72
N. Y.	V	19	F	59.9 ± 8.4	39.4	1.52
Conn.	V, R	21	M	51.7 ± 7.3	30.2	1.71
N. Y.	V	21	M	49.3 ± 6.2	44.0	1.12
Mass.	V	22	M	174.0 ± 12.0	53.2	3.27
N. Y.	V	25	M	77.9 ± 9.1	43.2	1.80
Southeast:						
N. C.	V	0	M	39.3 ± 10.0	32.1	1.22
Md.	V	2	M	142.0 ± 17.0	27.4	5.18
Md.	V	3	F	127.0 ± 18.0	34.8	3.64
Md.	V	5	M	115.0 ± 11.0	31.8	3.61
N. C.	V	5	F	81.7 ± 10.0	26.3	3.10
Md.	V	6	F	125.0 ± 13.0	36.7	3.40
Md.	V	8	M	115.0 ± 11.0	37.0	3.10
N. C.	V	9	M	78.8 ± 9.5	31.2	2.52
Md.	V	10	M	114.0 ± 11.0	46.8	2.43
Md.	V	10	M	128.0 ± 11.0	28.4	4.50
Fla.	V	11	M	44.6 ± 5.8	31.3	1.42
Md.	V	11	M	97.2 ± 8.4	33.8	2.87
Md.	V	15	F	226.0 ± 14.0	62.6	3.61
Md.	V	15	M	116.0 ± 12.0	56.6	2.04
Md.	V	16	M	155.0 ± 14.0	56.2	2.75
Md.	V	17	M	200.0 ± 16.0	52.7	3.79
Md.	V	18	M	125.0 ± 13.0	61.6	2.02
Md.	V	18	M	175.0 ± 14.0	67.4	2.59
Md.	V	18	M	145.0 ± 12.0	58.8	2.46
S. C.	V	18	M	131.0 ± 11.0	46.8	2.79
Ky.	V	19	M	137.0 ± 9.0	73.1	1.87
Md.	V	20	M	111.0 ± 13.0	60.2	1.84
Md.	V	20	M	113.0 ± 13.0	56.3	2.00
Md.	V	20	F	93.3 ± 8.7	56.4	1.65
Md.	V	20	M	118.0 ± 12.0	58.2	2.02
Md.	V	21	M	79.6 ± 10.0	54.7	1.45
Md.	V	21	M	124.0 ± 17.0	59.8	2.07
Md.	V	21	M	71.0 ± 9.9	37.1	1.91
Md.	V	22	M	145.0 ± 11.0	54.6	2.65

See footnotes at end of table.

Table 1. Strontium-90 in human bone, January–March 1967—Continued

Bone region and State of residence	Bone [a] type	Age [b] (years)	Sex	Strontium-90 concentration (pCi/kg bone)	Calcium concentration (g/kg bone)	$^{90}Sr/Ca$ (pCi/g)
Southeast: (continued)						
Md:	V	23	F	120.0 ± 14.0	58.5	2.05
N. C:	V	23	F	81.0 ± 10.0	47.9	1.69
Md:	V	24	M	100.0 ± 12.0	57.1	1.75
Md:	V	24	M	173.0 ± 12.0	67.7	2.55
Md:	V	24	M	68.6 ± 11.0	41.5	1.65
Md:	V	24	F	67.7 ± 10.0	56.5	1.19
Central:						
Wis:	V	0	F	68.7 ± 17.0	52.9	1.29
Wis:	V	1	M	92.5 ± 14.0	29.6	3.12
Wis:	V	1	F	87.1 ± 13.0	36.3	2.39
Wis:	V	1	M	143.0 ± 12.0	31.9	4.48
Wis:	V	1	M	47.5 ± 9.1	30.9	1.53
Wis:	V	2	F	60.8 ± 9.3	27.0	2.25
Ohio:	V	3	F	73.9 ± 10.0	32.7	2.25
Wis:	V	3	M	123.0 ± 11.0	29.7	4.14
Wis:	V	3	M	69.5 ± 7.3	25.7	2.70
Ohio:	V	3	F	191.0 ± 15.0	50.4	3.78
Ohio:	V	5	M	91.7 ± 16.0	32.5	2.82
Ohio:	V	6	M	107.0 ± 11.0	54.7	1.95
Ohio:	V	7	F	208.0 ± 13.0	34.5	6.02
Ohio:	V	8	F	59.2 ± 10.0	32.5	1.82
Ohio:	V	8	F	78.0 ± 11.0	55.2	1.41
Ohio:	V	11	M	150.0 ± 12.0	61.0	2.45
Ohio:	V	12	M	195.0 ± 15.0	73.4	2.65
Minn:	V	12	M	87.1 ± 10.0	45.5	1.91
Ohio:	V	15	M	130.0 ± 10.0	58.7	2.21
Ohio:	V	16	F	155.0 ± 9.7	68.7	2.25
Ohio:	V	16	M	136.0 ± 9.8	70.8	1.92
Mo:	V	16	M	154.0 ± 11.0	60.3	2.55
Minn:	V	16	M	100.0 ± 10.0	36.6	2.73
Mich:	V	21	M	59.6 ± 7.6	47.4	1.25
Ohio:	V	16	M	472.0 ± 26.0	82.1	5.74
Ohio:	V	17	M	157.0 ± 9.6	70.4	2.23
Ohio:	V	17	M	132.0 ± 10.0	60.7	2.17
Ohio:	V	17	M	120.0 ± 9.6	63.8	1.88
Ohio:	V	18	M	180.0 ± 12.0	73.4	2.45
Ohio:	V	18	M	109.0 ± 10.0	66.3	1.64
Ohio:	V	18	F	135.0 ± 12.0	65.9	2.04
Ohio:	V	18	M	175.0 ± 16.0	74.1	2.36
Ohio:	V	18	M	160.0 ± 15.0	88.7	1.80
Ohio:	V	19	M	156.0 ± 14.0	71.8	2.17
Ohio:	V	19	F	181.0 ± 13.0	83.6	2.16
Ohio:	V	19	M	120.0 ± 11.0	78.7	1.52
Ohio:	V	19	M	223.0 ± 15.0	75.3	2.96
Ohio:	V	20	M	115.0 ± 8.9	73.0	1.57
Ohio:	V	21	M	155.0 ± 9.6	89.1	1.73
Ohio:	V	21	F	108.0 ± 9.5	73.9	1.46
Ohio:	V	21	M	164.0 ± 11.0	61.1	2.68
Ohio:	V	22	M	125.0 ± 9.6	77.1	1.62
Ohio:	V	24	F	138.0 ± 10.0	72.5	1.90
Ohio:	V	24	M	161.0 ± 11.0	75.8	2.12
Ohio:	V	25	M	92.3 ± 8.9	67.3	1.37
Ohio:	V	25	F	102.0 ± 7.8	97.9	1.04
Ohio:	V	25	M	72.5 ± 10.0	72.5	1.00
Ohio:	V	25	M	110.0 ± 8.9	81.6	1.34
Minn:	V	25	M	93.2 ± 15.0	40.5	2.30
Delta:						
La:	V	1	M	274.0 ± 21.0	37.2	7.36
La:	V, R	5	F	112.0 ± 12.0	39.0	2.87
Miss:	V	6	F	180.0 ± 13.0	32.2	5.59
La:	V, R	7	F	186.0 ± 17.0	36.7	5.06
La:	V, R	11	F	104.0 ± 11.0	40.2	2.58
La:	V	21	M	68.9 ± 7.0	44.5	1.54
Northwest:						
Oreg:	V	0	M	50.2 ± 10.0	27.7	1.81
Oreg:	V	1	M	82.3 ± 10.0	32.0	2.57
Oreg:	V	1	M	113.0 ± 11.0	28.8	3.92
Oreg:	V	3	M	107.0 ± 10.0	28.8	3.71
Oreg:	V	9	M	76.3 ± 9.2	39.3	1.94
Oreg:	V	13	M	118.0 ± 10.0	41.0	2.87
Wash:	V	14	M	109.0 ± 8.0	48.5	2.24
Oreg:	V	21	M	75.3 ± 9.4	47.8	1.57
Wash:	V	21	F	140.0 ± 11.0	53.7	2.60
Wash:	V	22	M	75.3 ± 9.5	41.5	1.81
Wash:	V	22	F	58.7 ± 10.0	44.4	1.32
Alaska	R	13	M	150.0 ± 78.0	33.0	8.64
Alaska	R	17	M	838.0 ± 53.0	57.0	5.33
Alaska	R	17	F	677.0 ± 50.0	55.0	4.36
Alaska	R	22	F	182.0 34.0	52.0	1.19
Southwest:						
Tex:	V	17	M	150.0 ± 11.0	65.6	2.28
Calif:	V	22	F	88.5 ± 9.5	53.1	1.66
Tex:	V	23	M	34.2 ± 11.0	37.0	0.92

[a] Type of bone: V, vertebrae; R, rib; F, femur. [b] Age given as of last birthday prior to death. [c] Two standard deviation counting error.

tivity. For the purpose of maintaining analytical reproducibility, duplicate analyses are performed on 10 to 20 percent of the samples introduced randomly into the schedule of analysis. To further check and maintain analytical accuracy, samples are analyzed periodically and crosscheck analyses are carried out quarterly with the Health and Safety Laboratory of the AEC, which performs similar analyses.

The analytical results for strontium–90 in individual bones from persons dying during the first quarter (January–March) of 1967 are presented in table 1 in order of increasing age within each geographical region. These regions are indicated in figure 1. Reported values are given in picocuries of strontium–90 per kilogram of bone (as a rough indication of dose) and per gram of calcium (for comparison with other data and for purposes of model development). Two-sigma counting errors are reported for the bone concentration.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2–5*).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1966	February 1967
April–June 1966	March 1967
July–September 1966	July 1967
October–December 1966	September 1967

REFERENCES

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(*2*) WEISS, E. S., W. H. LAND, K. H. FALTER, and R. M. HALLISEY. Strontium–90 content of human bones, 1961–1963. Radiol Health Data 5:231–239 (May 1964).

(*3*) PUBLIC HEALTH SERVICE, NORTHEASTERN RADIOLOGICAL HEALTH LABORATORY. Analysis of environmental samples, chemical and radiochemical procedures, NERHL 64–1. Northeastern Radiological Health Laboratory, Winchester, Mass. (April 1964).

(*4*) GAFFNEY, G. W., R. M. HALLISEY, M. S. MILLER, and A. S. GOLDIN. Strontium–90 in human bone, 1962–1963. Radiol Health Data 5:620–628 (December 1964).

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Environmental Levels of Radioactivity at Atomic Energy Commission Installation

The U. S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of data from the environmental radioactivity monitoring reports follow for the Atomics International and Savannah River Plant.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Atomics International [1] July–December 1967

North American Rockwell Corporation
Canoga Park, California

Atomics International, a division of North American Rockwell Corporation, has been engaged in atomic energy research and development since 1946. The company designs, develops, and constructs nuclear reactors for central station and compact power plants and for medical, industrial, and scientific applications.

The company headquarters is located in Canoga Park, Calif., approximately 23 miles northwest of downtown Los Angeles. The 290-acre Nuclear Development Field Laboratory (Santa Susana Facility), equipped with extensive testing facilities for the support of advanced nuclear studies, is in Ventura County, in the Simi Hills approximately 29 miles northwest of downtown Los Angeles. The location of the above sites in relation to nearby communities is shown in figure 1.

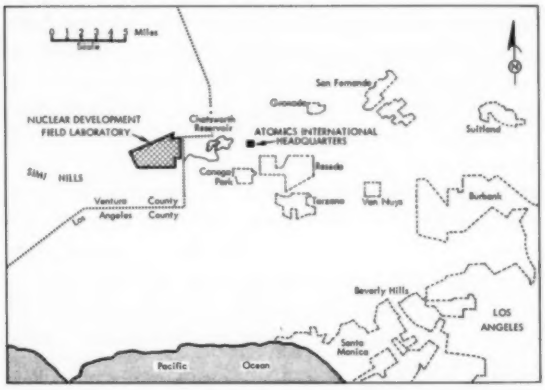

Figure 1. Atomics International facilities and vicinity

The basic concept of radiological hazard control at Atomics International encourages total containment of radioactive materials and, through rigid operational controls, minimizes effluent releases and external radiation levels. The environmental monitoring program provides a check on the effectiveness of radiological safety procedures and of engineering safeguards incorporated into facility design.

The environs of Atomics International headquarters and Nuclear Development Field Laboratory (NDFL) are surveyed monthly to determine the concentration of radioactivity in typical surface soil, vegetation, and water samples. In addition, continuous environmental air monitoring at the sites provides information concerning airborne particulate radioactivity.

Air monitoring

Environmental air sampling is conducted continuously at the headquarters and NDFL sites with automatic air samplers operating on 24-hour sampling cycles. Airborne particulate radioactivity is collected on HV–70 filter paper which is automatically changed at the end of each sampling period. The filter is removed from the sampler and counted after the radioactivity is allowed to decay for at least 72 hours. The volume of a typical daily environmental air sample is approximately 20-cubic meters. The average concentration of long lived beta-gamma radioactivity on airborne particulates is presented in table 1 for the first and the last half of 1967.

Table 1. Beta-gamma radioactivity of airborne particulates, Atomics International, 1967

Location	January-June 1967		July-December 1967	
	Number of samples	Average concentration (pCi/m³)	Number of samples	Average concentration (pCi/m³)
Headquarters	353	0.68	359	0.10
NDFL	1,243	0.66	1,157	0.12

Water monitoring

Process water used at the NDFL is obtained from Ventura County Water District No. 10 and distributed onsite by the same piping system previously used when process water was supplied by onsite wells. Pressure is provided by elevated storage tanks, one 50,000-gallon and one 500,000-gallon tank onsite. While clinically potable, the water is not used for drinking. Bottled potable water is delivered by a vendor and is not analyzed. Water from the

[1] Summarized from Environmental Monitoring, semiannual report, July 1, 1967 to December 31, 1967 and annual report 1967," Atomics International, Division of North American Rockwell Corporation.

pipe system is sampled monthly at two locations. The average radioactivity concentration in process water is presented in table 2.

Table 2. Process water radioactivity, NDFL site Atomics International, 1967

Type of radioactivity	January-June 1967		July-December 1967	
	Number of samples	Average concentration (pCi/liter)	Number of samples	Average concentration (pCi/liter)
Alpha	12	0.09	12	0.016
Beta-gamma	12	[a] 6.8	12	5.5

[a] Erroneously reported as 3.4 pCi/liter for the first half of 1967.

Water samples are also collected monthly at Chatsworth Reservoir which is operated by the Los Angeles City Department of Water and Power. Normally, one water sample is obtained from the lake surface and a second sample is obtained from the reservoir water supply inlet located on the north side of the lake. The average radioactivity for both surface and supply water samples is presented in table 3.

Table 3. Chatsworth Reservoir water radioactivity Atomics International, 1967

Sample	Type of radioactivity	January-June 1967		July-December 1967	
		Number of samples	Average concentration (pCi/liter)	Number of samples	Average concentration (pCi/liter)
Lake surface	Alpha	6	0.29	6	0.32
	Beta-gamma	6	8.7	6	7.6
Supply inlet	Alpha	6	0.26	6	0.30
	Beta-gamma	6	6.5	6	5.5

Surface discharged waters from NDFL facilities drain into holding reservoirs on adjacent property. When full, the main reservoir is drained into Bell Creek, a tributary of the Los Angeles River in the San Fernando Valley, Los Angeles County. Pursuant to the requirements of Los Angeles Regional Water Quality Control Board Resolution 66–49 of September 21, 1966, an environmental sampling station has been established in Bell Creek Canyon approximately 3.4 miles downstream from the south NARC Boundary. Samples, obtained and analyzed monthly, include stream-bed mud, vegetation, and water. Average radioactivity concentrations in the main holding reservoir and Bell Creek samples are presented in table 4.

Table 4. Radioactivity in the Main Holding reservoir [a] and Bell Creek, Atomics International July–December 1967

Sample description (units)	Number of samples	Alpha radioactivity	Beta radioactivity
Reservoir station 6 [a] (pCi/liter)	6	0.18	7.5
Reservoir station 12 [a] (pCi/liter)	6	.16	7.0
Bell Creek mud (pCi/g)	6	.41	25
Bell Creek vegetation (pCi/g ash)	6	.42	120
Bell Creek water (pCi/liter)	6	.08	4.2

[a] Locations not shown on figure 1.

Soil and vegetation monitoring

Soil and vegetation are regularly sampled at 24 locations. Twelve sampling stations are located within the boundaries of Atomics International's sites and are referred to as "onsite" stations. The remaining 12 stations, located within a 10-mile radius of the sites, are referred to as "offsite" stations.

Surface soil types available for sampling range from decomposed granite to clay and loam. Samples are taken from the top half-inch layer of ground surface. The soil samples are packaged and sealed in plastic containers and returned to the laboratory for analysis. Radioactivity in soil samples is presented in table 5.

Table 5. Radioactivity in the soil, Atomics International

Area	Type of radioactivity	January-June 1967		July-December 1967	
		Number of samples	Average concentration (pCi/g)	Number of samples	Average concentration (pCi/g)
Onsite	Alpha	72	0.40	72	0.43
	Beta-gamma	72	27	72	28
Offsite	Alpha	24	0.36	24	0.41
	Beta-gamma	24	25	24	24

Vegetation samples obtained in the field are of the same plant type wherever possible, generally, sunflower or wild tobacco plant leaves. These types maintain a more active growth rate during the dry season than do most natural vegetation indigenous to the local area. Vegetation leaves are stripped from plants and transferred to the laboratory for analysis.

Plant root systems are not routinely sampled. Radioactivity in vegetation samples is presented in table 6.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
Second half of 1966	August 1967
First half 1967	March 1968

Table 6. Radioactivity in vegetation, Atomics International

Area	Type of radioactivity	January–June 1967		July–December 1967	
		Number of samples	Average concentration (pCi/g ash)	Number of samples	Average concentration (pCi/g ash)
Onsite	Alpha	72	0.48	72	0.74
	Beta-gamma	72	425	72	147
Offsite	Alpha	24	0.32	24	0.44
	Beta-gamma	24	658	24	167

2. Savannah River Plant [2] July–December 1967

E. I. duPont de Nemours
Aiken, South Carolina

The Savannah River Plant (SRP), built and operated for the Atomic Energy Commission by E. I. duPont de Nemours and Company, occupies an area of 312-square miles along the Savannah River, 22 miles downstream from Augusta, Ga. Production facilities include a fuel preparation area, four reactors, two fuel separation areas, and a heavy water production plant. A basic goal in plant operation is total containment of radioactive waste. Although some very low-level gaseous and liquid wastes are discharged to the environment in controlled releases, dispersal is adequate to ensure environmental concentrations below recommended guides.

The DuPont environmental monitoring group has maintained a continuous monitoring program since 1951 (before plant startup) to determine the concentrations of radioactive materials in a 1,200-square mile area outside the plant. Included in this area are parts of Aiken, Barnwell, and Allendale counties in South Carolina, and Richmond, Burke, and Screven counties in Georgia. This surveillance determines the magnitude and origin of any radioactivity above natural levels. Measured concentrations of radionuclides in air, water, and milk are compared with the maximum permissible concentrations (MPC) recommended by the International Commission on Radiological Protection (ICRP), or the daily intake guides recommended by the Federal Radiation Council (FRC).

Sensitive instruments, which can detect traces of radioactive materials far below concentrations of hazard significance, are used to determine radioactivity in the environs. Plant-released radioactivity cannot be readily distinguished from weapons tests fallout, and both are included in the reported concentrations. Maximum and minimum values given are for individual samples collected during the report period.

Atmospheric monitoring

Concentrations of radioactive materials in the atmosphere were measured by biweekly analyses of air filters collected at five monitoring stations near the plant perimeter and 10 stations around a circle of about 25-miles radius from the center of the plant (figure 2). Deposition rates of radioactive material at each station were also determined by monthly analyses of rainwater ion exchange columns (fallout collectors). The monitoring stations are spaced so that a significant release of airborne radioactivity by SRP would be detected regardless of the prevailing wind. All stations operate continuously. Four additional air monitoring stations at Savannah and Macon, Ga., and at Columbia and Greenville, S.C., are so distant from SRP that the effect of SRP operations is negligible; they are reference points for determining background radioactiv-

[2] Summarized from "Effect of the Savannah River Plant on Environmental Radioactivity, Semiannual Report, July–December 1967," DPST 68-30-1.

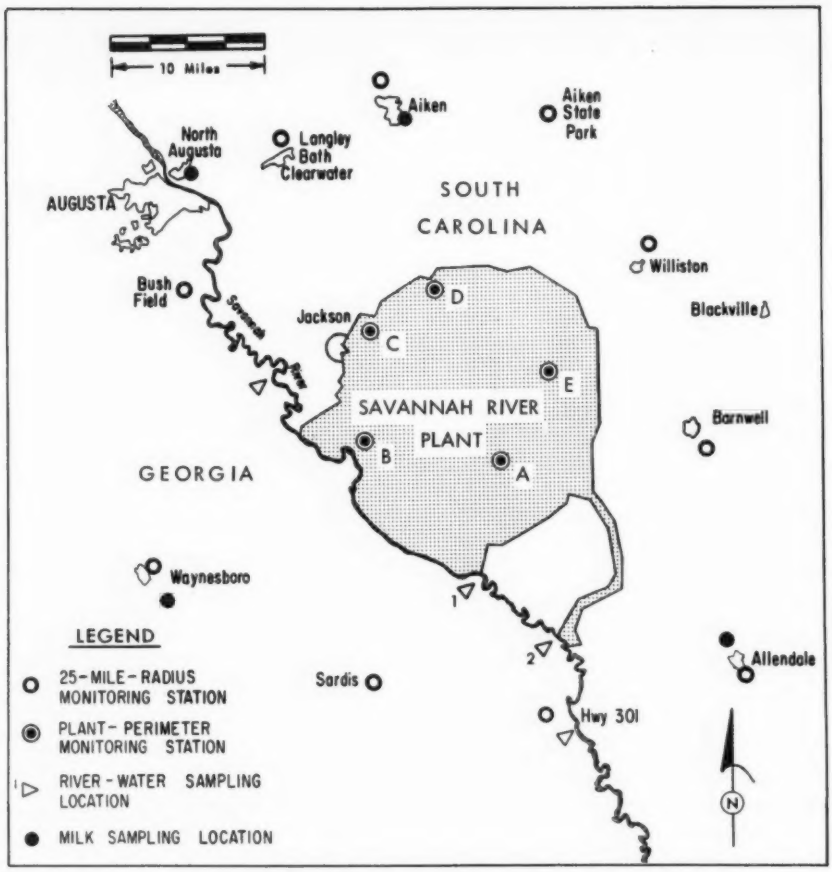

Figure 2. Environmental sampling locations, Savannah River Plant

ity levels (figure 3). This system permits comprehensive surveillance of atmospheric radioactivity and also makes it possible to differentiate between weapons test fallout and SRP releases.

The small amount of filterable beta radioactivity released to the atmosphere, primarily from the fuel separations areas, was obscured by fallout. The influence of the nuclear tests which resumed in September 1961 is shown in figure 4. The rises in early 1964, 1965, and 1966 were the result of the anticipated spring increases in the mixing of stratospheric debris into the troposphere. The concentrations of radionuclides in air during July–December 1967, were the lowest ever observed in this area.

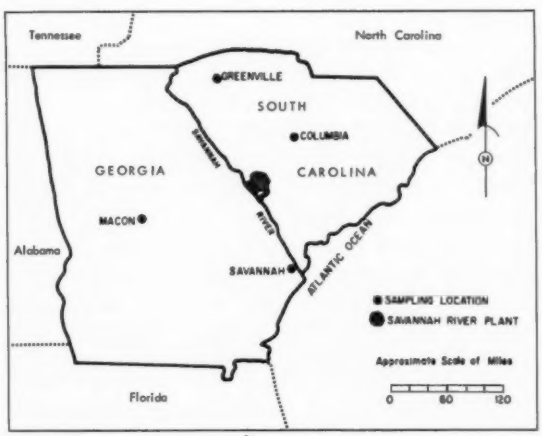

Figure 3. Distant air monitoring stations, Savannah River Plant

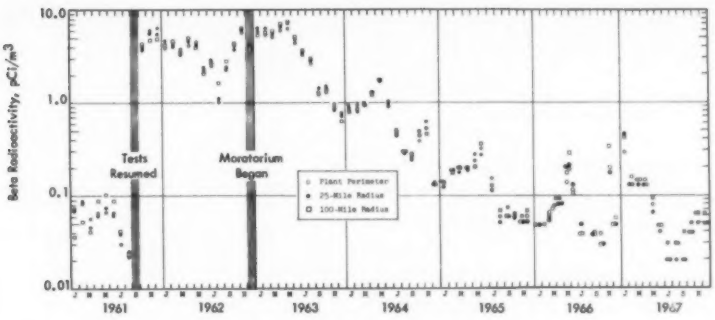

Figure 4. Influence of weapons tests

Radioactivity in air, determined from filter analyses, is shown in table 7. The July–December 1967 concentrations of filterable beta radioactivity (0.03 pCi/m³) and alpha radioactivity (0.0006 pCi/m³) in air were 0.03 and 0.8 percent of the respective MPC's. Tritium oxide concentrations in air, at the plant perimeter and at the 25-mile stations, did not exceed 0.1 percent of the MPC. Iodine–131 concentrations in routine air samples were less than 0.02 pCi/m³, the lower detection limit, throughout the period.

Deposition of fallout during July–December 1967 totaled 1 nCi/m² at the plant perimeter locations and 1 nCi/m² at 25-mile radius locations; comparable values for the first half of 1967 were 23 and 20 nCi/m². Deposition at each sampling location is presented in table 8.

Algae and fish in Savannah River

Fish, predominantly bream, and indigenous algae, primarily green (*Vaucheria*) and blue-green (*Phormidium*), were collected weekly upstream from, adjacent to and downstream from the Savannah River Plant. Determination of radionuclides in algae is important because algae concentrate certain radionuclides and also because of the role of algae in the food chain of aquatic organisms. Beta radioactivity concentrations in algae and fish adjacent to and downstream from SRP indicate some minor contribution by SRP. Although measurably higher

Table 7. Radioactivity in air, Savannah River Plant, July–December 1967

Filter analysis	Average concentrations (pCi/m³)															
	Plant perimeter locations						25-mile radius locations									
	A	B	C	D	E	Average	Aiken airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Highway 301	Average
Alpha particle emitters [a] (multiply by 10^{-3})																	
Maximum	1.3	1.2	2.3	1.9	1.5		1.2	1.3	1.4	1.3	1.3	1.2	1.7	1.2	1.2	1.5	
Minimum	.3	ND	0.4	ND	ND		0.3	0.4	ND	0.4	0.4	0.4	0.3	0.4	0.3	ND	
Average	.7	.7	1.0	0.9	0.7	0.8	0.8	0.7	0.6	0.6	0.8	0.7	0.7	0.7	0.6	0.6	0.7
Nonvolatile beta-particle emitters [b]																	
Maximum	0.07	0.07	0.05	0.10	0.06		0.05	0.05	0.04	0.07	0.05	0.03	0.03	0.06	0.07	0.05	
Minimum	.02	ND	.02	.02	.02		.02	.02	.02	.02	.02	.02	.02	.02	.02	.01	
Average	.03	.03	.04	.04	.03	.03	.03	.02	.02	.03	.03	.02	.02	.03	.03	.03	.03
Specific radionuclides (averages)	Composite sample						Composite sample										
Strontium-89, 90	<0.005						<0.003										
Cesium-137	< .006						< .005										
Cerium-141, -144	< .01						< .01										
Zirconium-niobium-95	< .02						< .02										

[a] Sensitivity of analysis—3.0×10^{-4} pCi/m³; ICRP Maximum Permissible Concentration: 0.07 pCi/m³.
[b] Sensitivity of analysis—0.006 pCi/m³; ICRP Maximum Permissible Concentration: 100 pCi/m³.
ND, nondetectable, less than sensitivity of analysis.

Table 8. Total fallout deposited, Savannah River Plant, July–December 1967

Radionuclide	Deposition (nCi/m²)															
	Plant perimeter locations						25-mile radius locations									
	A	B	C	D	E	Average	Aiken airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Highway 301	Average
Alpha [a]	3.05	1.85	1.81	2.01	2.66	2.28	1.27	1.93	1.62	0.54	1.47	2.62	1.39	1.93	3.09	1.85	1.78
Strontium-89	0.12	0.19	0.04	ND	0.08	0.08	ND	ND	0.31	.27	ND	0.12	0.12	0.08	ND	0.15	0.12
Strontium-90	.23	.23	.27	0.35	.31	.27	0.15	0.31	.12	.12	0.27	.15	.19	..15	0.19	.19	.19
Cesium-137	.69	.93	.42	.58	.35	.58	.27	.27	.12	ND	.69	.50	.96	.46	.12	.66	.39
Cerium-141, -144	ND	ND	ND	.58	ND	.12	.62	ND	ND	.58	ND	ND	ND	ND	ND	.54	.15
Zirconium-niobium-95	.19	ND	.12	.08	.15	.12	.08	.23	.12	ND	.15	.19	.35	ND	ND	.08	.12
Beryllium-7	16.13	12.31	9.42	14.24	9.15	12.24	13.12	7.60	6.10	2.24	8.96	11.73	7.18	6.33	7.76	7.72	7.87

[a] Multiply by 10^{-2}
ND, nondetectable, less than sensitivity of analysis.

than similar material collected at the control station 3 miles upstream from SRP, the slight increase is of no biological significance.

Specific radionuclide analyses were made on algae and fish collected from the Savannah River. Radiocesium and radiostrontium were found consistently in river algae; whereas cerium–141, –144, chromium–51, zirconium-niobium–95, manganese–54, zinc–65, and cobalt–60 were detected less frequently. Also, radiostrontium (maximum, 18 pCi/g, wet weight) was detected in bone tissue of river fish, and radiocesium (maximum 41 pCi/g, wet weight) was detected in the flesh tissue. Radiozinc and phosphorus–32 were detected less frequently in these tissues. The maximum concentrations of phosphorus–32 detected in bone and flesh tissues of river fish were 102 pCi/g and 17 pCi/g, respectively.

Water monitoring

The plant site is drained by five streams which flow several miles through the reservation before reaching the river (figure 5). In January 1965, the Beaufort-Jasper Water Authority began operation of a new treatment facility to furnish drinking water, partially supplied from the Savannah River, to most of Beaufort County, South Carolina. Water is supplied through a new canal from the river at a location about 90 miles below the SRP. The city of Savannah also supplements its domestic well water supply with river water during periods of peak demand.

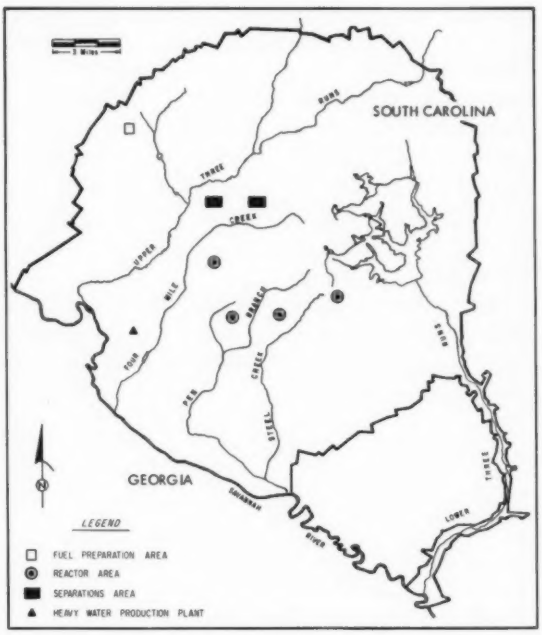

Figure 5. SRP production and effluent streams

Communities near SRP get domestic water from deep wells or surface streams. Public water samples were collected and analyzed from 14 surrounding towns in October. There was no evidence that SRP contributed radioactivity to drinking water supplies; concentrations of alpha radioactivity (1.2 pCi/liter) and beta radioactivity (6 pCi/liter) were essentially the same as those observed before plant startup.

River water, analyzed weekly, was sampled continuously at four locations, as shown in figure 2. Average concentrations of specific radionuclides found in river water during July–December 1967 are in table 9.

Table 9. Average concentration of radionuclides in Savannah River water, July–December 1967

Radionuclide	Concentration (pCi/liter)			
	Sensitivity of analysis	Control (3 miles upstream from plant)	Highway 301 (10 miles downstream from plant)	Percent MPC at Highway 301
Tritium-3	600	800	7,400	0.25
Ruthenium-103, -106	3.2	ND	ND	<0.03
Cerium-141, -144	2.5	ND	ND	<0.02
Cesium-134, -137	0.6	ND	1.6	<0.01
Neptunium-239	2.2	ND	1.7	<0.002
Barium-lanthanum-140	1.6	ND	ND	<0.01
Zirconium-niobium-95	0.5	ND	ND	<0.001
Chromium-51	4.3	ND	6.7	0.0003
Strontium-89	0.3	ND	1.5	0.05
Iodine-131	0.5	ND	0.7	0.23
Strontium-90	0.01	0.6	1.0	0.25
Cobalt-60	1.4	ND	ND	<0.003
Zinc-65	1.1	ND	ND	<0.001
Manganese-54	0.4	ND	ND	<0.0004

ND, nondetectable, less than sensitivity of analysis.

Tritium, and trace amounts of cesium–137, neptunium–239, iodine–131, chromium–51, strontium–89, and strontium–90, released mainly from reactor areas, were the radionuclides of SRP origin detectable in river water at the downstream location. Strontium–90 and tritium from worldwide fallout were also detected in river water upstream from SRP. The tritium concentrations in raw water collected from the Beaufort-Jasper Water Plant averaged 4,000 pCi/liter (0.1 percent of the MPC) during the 6-month report period. The annual radiation exposure of an individual in this population due to the consumption of water containing the very low concentration of tritium is only 0.4 mrem. The radiation dose was determined by analysis of urine (99 samples) collected from Beaufort residents during 1967.

Tritium, a beta-particle emitter and the most abundant radionuclide released to the river, is produced by neutron irradiation of heavy water moderator in the reactors. Chronium–51, the second most abundant radionuclide released to the river, is produced by neutron irradiation of stable chromium (a component of the stainless steel used in reactor parts). The tritium and chromium–51 concentrations in river water averaged 0.25 and 0.0003 percent of the MPC, respectively.

Vegetation

Radioactive contamination of growing plants may result from deposition on foliar surfaces or absorption of radioactive materials from the soil.

Grass samples were collected at seven locations along the plant perimeter and at nine other locations along a 25-mile radius route. (These are not designated on figure 2). Samples from each quadrant of the plant site and of the surrounding area were composited for monthly analysis. Radionuclides in grass samples were from fallout. Alpha-particle emitters averaged 0.1 pCi/g at the plant perimeter and 25-mile radius locations as compared to 0.2 pCi/g during January–June 1967; gamma-ray emitters averaged 4.8 and 5.3 pCi/g, respectively, as compared to 32 and 37 pCi/g for January–June 1967.

Milk

Milk was sampled at three dairies within a 25-mile radius of SRP, as shown in figure 2. Samples which were collected biweekly, were analyzed for tritium, radiocesium, and radioiodine. Strontium–90 determinations were made quarterly. Milk produced in the area and sold by major distributors was also analyzed for these radionuclides. Results from analyzing milk for radioactivity during July–December 1967 are in table 10.

Table 10. Radioactivity in milk from local dairies Savannah River Plant, July–December 1967

Location of local dairies	Concentration (pCi/liter)				
	Tritium [a]			Strontium-90 [b]	
	Maximum	Minimum	Average	Sept 1967	Dec 1967
Aiken	5.0×10^3	ND	ND	13	16
North Augusta	8.0×10^3	ND	ND	12	11
Waynesboro	7.0×10^3	ND	ND	14	8
Major distributors [c]	6.0×10^3	ND	ND	9	10

[a] Sensitivity of analysis—3,000 pCi/liter.
[b] Sensitivity of analysis 1.0 pCi/liter.
[c] Milk produced in local dairies, but sold by major distributors.
ND, nondetectable, less than sensitivity of analysis.

Average concentrations of three radionuclides in milk (less than 30 pCi/liter for cesium–137, 12 pCi/liter for strontium–90, and less than 5 pCi/liter for iodine–131) were consistent with values reported by the U.S. Public Health Service for most sections of the United States during July–December 1967. Tritium in local milk, when present, is assumed to be associated with plant operations. The average tritium level was less than the sensitivity of the analysis, which allows detection of concentrations of 3,000 pCi/liter (1 percent of the MPC for water).

Food

Sixty-two samples representing 4 food categories (fruit, grain, leafy vegetable, and poultry) were collected during the summer and fall of 1967 at 14 localities in the 6 countries surrounding SRP (not shown on figure 5). With the exception of grains, all foods were prepared for analysis in a manner similar to that used to prepare them for eating. Peelings, seeds, and other nonedible parts were removed.

Wheat, containing the whole grains only, and oats, containing both grains and husks, were processed unwashed. Gamma-ray spectrometry was used to analyze samples for cerium–141, –144, ruthenium–103, –106, iodine–131, cesium–137, manganese–54, and zirconium-niobium–95. Radiostrontium and alpha radioactivity (uranium and plutonium) were determined by radiochemical analysis.

SRP contribution to the levels of radioactivity in foods were so low in 1967 as to be indistinguishable from fallout. With the exception of cesium–137 and strontium–90, all radionuclides in food were near or below levels of detection. The amount of strontium–90 and cesium–137 were slightly lower than during 1966; maximum concentrations were 0.62 pCi/g for strontium–90 in collards and 0.08 pCi/g for cesium–137 in grain. Alpha radioactivity in food was about the same as in the 1966 samples (table 11).

Table 11. Radioactivity in agricultural products Savannah River Plant, 1967

Products	Number of samples	Concentration (pCi/g wet weight)					
		Strontium-90		Cesium-137		Alpha emitters	
		Average	Maximum	Average	Maximum	Average	Maximum
Collards	14	0.61	1.03	ND	0.07	0.055	0.220
Plums	14	.02	.04	ND	.09	.002	.004
Oats, rye and wheat	14	.18	.35	0.08	.14	.006	.023
Corn	14	.02	.05	.06	.21	.002	.006
Chicken	6	.03	.06	ND	.04	.003	.007
Sensitivity of analysis		.02		.02		.002	

ND, nondetectable.

Environmental gamma radiation levels

Monthly measurements of environmental gamma radiation were made with thermoluminescent dosimeters. The July–December 1967 data (shown in table 12), are characteristic of measurements observed at individual stations for the past several years.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1966	September 1967
January–June 1967	February 1968

Table 12. Environmental gamma radiation, Savannah River Plant, July–December 1967

Filter analysis	Exposure (mR/day)															
	Plant perimeter locations						25-mile radius locations									
	A	B	C	D	E	Average	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Highway 301	Average
Maximum	0.50	0.28	0.41	0.29	0.33		0.22	0.24	0.30	0.36	0.36	0.35	0.33	0.31	0.27	0.35	
Minimum	.18	.16	.20	.15	.17		.16	.13	.19	.16	.17	.19	.18	.17	.18	.19	
Average	.29	.22	.26	.21	.24	0.24	.20	.17	.24	.24	.24	.25	.24	.23	.22	.24	0.23

Reported Nuclear Detonations, May 1968

The U.S. Atomic Energy Commission announced one underground nuclear test for the month of May. On May 17, 1968, an underground nuclear test of low-intermediate yield (20 to 200 kilotons TNT equivalent) was conducted at the AEC Nevada Test Site.

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June 1968

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